A Management Plan for the Yampa River Basin

To promote recovery of its endangered fishes
while allowing current water depletions to continue
and an additional increment of depletions
to be developed in the future

Final Draft

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EXECUTIVE SUMMARY

The Colorado pikeminnow (*Ptychocheilus lucius*), humpback chub (*Gila cypha*), bonytail (*G. elegans*) and razorback sucker (*Xyrauchen texanus*) have been listed as endangered under the Endangered Species Act of 1973 (ESA). Endemic to the Colorado River Basin, these fishes have suffered declining populations throughout their historic range due largely to habitat loss or degradation and introduction of competitive and predatory nonnative fish species.

The importance of the Yampa River to these endangered fishes is significant. It provides critical habitat for Colorado pikeminnow from Craig, Colorado, downstream to its confluence with the Green River. Razorback sucker and Colorado pikeminnow spawn in the lower reaches of Yampa Canyon, which also harbors one of the few remaining populations of humpback chub in the Upper Colorado River Basin. Peak flows are particularly important in creating and maintaining spawning habitats for the endangered fishes in the Yampa River, as well as nursery habitats for Colorado pikeminnow and razorback sucker in the Middle Green River downstream from the Yampa.

The ESA encourages agencies to cooperate in resolving conflicts between water development and conservation of listed species. Consistent with this intent, the governors of Colorado, Utah and Wyoming, the Secretary of the Interior, and the Administrator of the Western Area Power Administration signed a Cooperative Agreement in 1988 establishing the Upper Colorado River Endangered Fish Recovery Program. The goal of the Recovery Program is to recover the endangered fishes while allowing for current and certain future water depletions from the Upper Colorado River Basin. A Recovery Action Plan outlines measures to benefit the endangered fishes. These measures include providing and protecting instream flows, acquiring and managing habitat, constructing fish passage facilities, managing nonnative fish, propagating and stocking endangered fishes into their historic habitats, and monitoring the status of fish populations and habitat.

The ESA also requires that "recovery goals" be developed which, among other things, incorporate "objective, measurable criteria which, when met, would result in a determination...that the species be removed from the list." If all recovery criteria are met, we expect that the endangered fishes can be downlisted and subsequently delisted within a reasonable length of time. Draft recovery goals for the four fish species recently were published. These goals include both numerical population criteria and habitat criteria and specifically address the five listing factors: (1) present or threatened destruction, modification, or curtailment of its habitat or range; (2) overutilization for commercial, recreational, scientific, or educational purposes; (3) disease or predation; (4) inadequacy of existing regulatory mechanisms; or (5) other natural or manmade factors affecting its continued existence. Other natural or manmade factors may include such imminent or potential threats as hybridization with closely related species and contamination with hazardous materials or other pollutants.

This management plan supports recovery of the endangered fishes while allowing for current depletions from the Yampa River Basin to continue to serve existing human needs in Colorado and Wyoming. In addition, it allows for an additional increment of depletions to be developed to meet future human needs through the year 2045. This plan quantifies current and projected future depletions and describes measures to preserve the natural ecosystem as current depletions continue and new depletions are developed, including specific actions to be taken to promote recovery of the listed species and criteria by which to measure the success of those recovery actions.

To implement this plan, the Fish and Wildlife Service (FWS) will sign a Cooperative Agreement with the States of Colorado and Wyoming. The FWS, through its participation in implementing this plan, will initiate an intra-Service consultation pursuant to Section 7 of the ESA. It is expected that the product of that consultation will be a Programmatic Biological Opinion for the Yampa River Basin to consider the impacts to listed species (not limited to the four endangered fish species) due to the depletions, as well as other non-depletive impacts addressed in the plan. It will also serve as a means to address incidental take for projects that otherwise would not be covered.

About 125,000 acre-feet (AF) of water currently is depleted each year from the Yampa River Basin in Colorado primarily for irrigation, electric power generation, reservoir evaporation, municipal and industrial uses. Irrigation depletes almost 88,000 AF, and power generation consumes another 17,000 AF. Wyoming estimates depletions of 43,000 AF from the Little Snake River, the largest tributary to the Yampa. Almost 27,000 AF is depleted for irrigation in Wyoming, and more than 14,000 AF is diverted out-of-basin to serve the City of Cheyenne. These depletions represent about 11% of the annual 1.5 million AF discharge of the Yampa River. Growth projections for the Yampa River Basin predict that by the year 2045 an additional 30,000 AF in Colorado and 23,000 AF in Wyoming will be depleted from the Yampa River. Colorado may also develop a second increment of 20,000 AF, for a total of 175,000 AF. These depletions could affect recovery of the listed fishes.

This plan is intended to offset the impacts to the endangered fishes due to both current and future depletions from the Yampa River Basin in Colorado and Wyoming. It encompasses depletions by direct flow diversions and small tributary reservoirs. This plan does not cover any new, large mainstem dams and reservoirs nor will it address impacts of depletions from the Green River mainstem or any of its tributaries other than the Yampa. Diversions from existing facilities are expected to have little impact on peak flows; however, new tributary reservoirs or large direct-flow diversions could diminish peak flows to the detriment of the endangered fishes. Recovery actions, and their development, are described below. Schedules to initiate and/or complete recovery actions will be specified by the Recovery Program upon incorporation or clarification of these actions in annual revisions to the Recovery Action Plan. The Recovery Program will be responsible for funding and implementing these recovery actions.

Nonnative fishes adversely impact endangered fishes and other native species by feeding upon and competing with native species. Recovery actions include measures to reduce the impacts of sportfish such as northern pike, smallmouth bass and channel catfish, and other nonnative fishes on the endangered fishes. Measures include screening reservoirs to prevent escapement of sportfish to the river, implementing stocking regulations to preclude stocking nonnative species to any water from which escapement to the river is likely, and active removal of nonnative fishes from the river. While some species may be lethally controlled, Yampa Basin residents desire to maintain their sport fishery. To accommodate this request, sport fish such as northern pike and smallmouth bass removed from the river will be placed in ponds and reservoirs accessible to the general public.

Yampa River flows during non-runoff periods (base flows) will be augmented to compensate for the impacts of depletions, but the need for augmentation will be tempered by the need to protect peak flows. This plan does not rely upon instream flow water rights to serve the flow needs of fishes nor does it preclude the State from filing for such rights in the future. The FWS adopted daily average base flow targets of 93 cubic feet per second (cfs) from July through October and 124 cfs from November through March. Daily average flows should not fall below these targets in the future with any greater frequency, magnitude or duration than they had historically.

A volume of 7,000 AF was estimated to satisfy 100% of augmentation needs in 9 out of 10 years, and partially satisfy those needs in the driest 10% of years. A practical approach was developed to augment flows for fishes, as necessary and available, using lower and upper flow thresholds that bracket the flow targets. When unaugmented flows fall below the lower threshold, augmentation would begin, and when augmented flows exceed the upper threshold, augmentation would cease.

Eleven augmentation water supply alternatives were identified and evaluated. Alternatives included both structural and non-structural options and utilized existing reservoirs, as well as other water sources as practicable. Each alternative relied upon one or more of the following potential sources:

- Steamboat Lake (2,000-7,000 AF by lease)
- Elkhead Reservoir (3,700-7,000 AF by lease, exchange and/or enlargement)
- Stagecoach Reservoir (1,300-7,000 AF by lease, exchange and/or enlargement)
- New tributary reservoir(s) (up to 1,300 AF)
- Other water leases (up to 1,300 AF)

Each of 11 alternatives was subjected to a preliminary feasibility analysis, using the following evaluation criteria: (1) ability to meet augmentation needs; (2) estimated cost; (3) impacts on State Parks and water-related recreation; (4) impacts on agriculture; and (5) impacts on peak flows.

The Recovery Program currently augments Yampa River base flows by leasing from the Colorado Division of Parks and Outdoor Recreation up to 2,000 AF per year out of Steamboat Lake. This volume has been adjudicated for instream flow use and is subleased to the Colorado Water Conservation Board for this purpose. This plan would extend the lease to serve a portion of the required 7,000 AF of augmentation.

However, this plan does not rely upon instream flow water rights to serve the flow needs of fishes nor does it preclude the State of Colorado from filing for such rights in the future. Although no one can guarantee that water rights will not be administered in the Basin in the future, this plan neither requires nor precludes such administration nor will it interfere in any way with water users in the Yampa Basin exercising their legitimate water rights consistent with relevant state and federal law, including interstate compacts.

The Recovery Program will identify and evaluate high-priority flooded bottomland habitats along the Middle Green River between Ouray and Jensen, Utah, acquiring an interest in the best habitats, and improving their habitat value by removing levees to allow spring floods to inundate floodplain depressions, overflow channels, backwaters and oxbows, which serve as nursery habitats for Yampa/Green river populations of razorback sucker and Colorado pikeminnow.

The Recovery Program will develop and implement remedial measures, as necessary, to restore native fish passage at instream barriers and reduce impacts of maintaining diversion structures within critical habitat on the Yampa River (Echo Park to Craig, Colorado). In addition, the Recovery Program will develop guidelines to facilitate fish passage at any new diversion structures and dams that may be built in critical habitat.

The Recovery Program will evaluate the potential for entrainment of Colorado pikeminnow by existing diversions on the Yampa River in the critical habitat reach, rectify any significant problems that it finds, and develop guidelines to reduce or eliminate entrainment at any diversion structures that may be built or modified in critical habitat.

The Recovery Program has developed genetic management goals for the endangered fishes: (1) prevent immediate extinction; (2) conserve genetic diversity through recovery efforts that will establish viable wild stocks by removing or significantly reducing factors that caused the population declines; (3) maintain the genetic diversity of captive-reared fish; and (4) produce genetically diverse fish for augmentation efforts. Supplementing the Middle Green/Lower Yampa razorback sucker population is a high priority of the Recovery Program. Bonytail were stocked in Lodore Canyon (Green River) and Echo Park (Yampa River) in 2000. Additional bonytail stocking is proposed.

Monitoring will be necessary to determine how well the endangered fishes are doing, and their prospects for recovery. Recovery is considered to have been achieved "when management actions and associated tasks....have been implemented and/or completed to allow genetically and demographically viable, self-sustaining populations to thrive under minimal ongoing management and investment of resources."

The status of listed species must be reviewed at least once every 5 years to determine if they should be "downlisted" from endangered to threatened status or "delisted" (i.e., removed from the list). Separate performance criteria will be developed for each of the above recovery actions to determine their contribution to the recovery of the endangered fishes. The status of endangered fish populations will be ascertained at 5-year intervals. Based on the results of monitoring, the Recovery Program will re-evaluate the effectiveness of its recovery actions and may modify those actions (i.e., using adaptive management) as it deems necessary and appropriate. The Recovery Program will implement any modifications or additions to the above recovery actions and bear the incremental costs resulting therefrom.

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LIST OF ACRONYMS AND ABBREVIATIONS

AF	- Acre-feet
CDOW	- Colorado Division of Wildlife
CDPOR	- Colorado Division of Parks and Outdoor Recreation
cfs	- Cubic feet per second
CRDSS	- Colorado River Decision Support System
CRWCD	- Colorado River Water Conservation District
CULR	- Consumptive Use and Loss Report
CWCB	- Colorado Water Conservation Board
DNM	- Dinosaur National Monument
DPS	- Distinct Population Segment
EA	- Environmental Assessment
ESA	- Endangered Species Act
FWS	- U.S. Fish and Wildlife Service
GOCO	- Great Outdoors Colorado
MAF	- Million acre-feet
MVP	- Minimum Viable Population
NEPA	- National Environmental Policy Act
NNSP	- Nonnative Stocking Procedures
NPS	- National Park Service
PBO	- Programmatic Biological Opinion
RIPRAP	- Recovery Implementation Program Recovery Action Plan
USBR	- U.S. Bureau of Reclamation
WAPA	- Western Area Power Administration

INTRODUCTION

Purpose and Need

The purpose of this management plan is to promote the recovery of four listed endangered fish species while allowing for current depletions from the Yampa River and its tributaries in Colorado and Wyoming to continue and for an additional increment of water development to serve projected human needs through the year 2045. This plan quantifies current and future depletions, describes how the listed fishes will be recovered and the natural ecosystem preserved as current depletions continue and new depletions are developed, identifies specific actions to be taken to support recovery of these species, and establishes criteria by which to measure success of those actions.

Hydrologic Setting

The Colorado River Basin encompasses 245,000 square miles in the southwestern United States and northern Mexico, roughly the same size as the Columbia River Basin, yet its annual average yield is less than 7% the yield of the Columbia. Moreover, demand for water in this arid region is so great that in most years the Colorado River no longer flows into the Sea of Cortez. Dammed and diverted for irrigation, municipal and industrial consumption, the Colorado River and its major tributaries have become a series of lakes and cold, clear tailwaters, which attenuate peak flows, increase base flows and significantly reduce or degrade the essential habitats of many endemic fish species adapted to warm, turbid, free-flowing rivers.

In November 1922, the Colorado River Compact was signed, allocating 15 million acre-feet (MAF) of the Colorado River equally between the Upper Basin states (Colorado, New Mexico, Utah and Wyoming) and Lower Basin states (Arizona, California and Nevada). This allocation, which exceeds the long-term average yield of 13.5 MAF, was based on a short-term estimate by the U.S. Bureau of Reclamation of 16.4 MAF during a wetter than average period. In reality, annual yield is highly variable, ranging from 4.4 MAF to more than 22 MAF. However, the Compact made no other allowance for drought conditions except to average the Upper Basin's 7.5-MAF obligation to the Lower Basin over a 10-year period (Gelt 1997). Lake Powell, a 27-MAF reservoir behind Glen Canyon Dam, allows the Upper Basin to store water during periods of surplus to meet its Compact obligations to the Lower Basin during periods of drought.

The Upper Colorado River Basin is defined by the gage at Lees Ferry near Page, Arizona. Glen Canyon Dam, 15 rivermiles (RM) upstream from Lees Ferry, serves as the physical boundary between Upper and Lower basins. The Upper Basin encompasses an area of roughly 108,000 square miles.

The mainstem Colorado River is joined by the Green River 216 RM upstream from Lees Ferry. The Green River subbasin delivers roughly half of the combined flow of these two rivers at their confluence. The Yampa River, the largest tributary to the Green River, delivers about half of the average annual discharge of the Green River at Jensen, Utah, about 197 RM upstream from the Colorado River. Other significant tributaries to the Green River are the White, Duchesne, Price and San Rafael rivers.

The Yampa River is the only stream of its size in the Upper Colorado River Basin that still exhibits a relatively natural hydrograph. Unimpeded by large dams and reservoirs or out-of-basin diversions, spring peak flows on the Yampa have changed very little from pre-development. Maximum flows at the Maybell gage have exceeded 24,000 cubic feet per second (cfs) with annual peak flows averaging about 10,000 cfs. Spring peaks result from melting snowpack accumulated at higher elevations during the winter. Severe thunderstorms also may produce transient peaks in the hydrograph. Snowmelt at lower elevations can produce early minor peaks prior to onset of the major peak. Spring runoff typically begins in late March and wanes by mid-July, but annual peak flows generally occur between mid-May and mid-June. Peak flows are particularly important in creating and maintaining spawning habitats for the endangered fishes in the Yampa, as well as nursery habitats of the Colorado pikeminnow and razorback sucker in the Middle Green River downstream from the Yampa confluence to Ouray, Utah. These habitats are critical to the recovery of the Yampa/Green River populations of these fish species. Flaming Gorge Dam and Reservoir (~3.8 MAF), located on the Green River about 65 RM upstream from the Yampa, impacts these habitats by reducing peak flows and elevating base flows. The Yampa River provides a more natural hydrograph in the Green River downstream from the Yampa.

A spring snowmelt hydrograph consists of three distinct elements: (1) ascending limb, (2) peak, and (3) descending limb. Each of these components serves a specific function to maintain the aquatic habitats essential for the endangered fishes, initiate pre-spawning and post-spawning migrations, cue spawning behavior, and transport larval fish to nursery habitats downstream.

Diversions due to existing facilities are expected to have little impact on peak flows; however, new reservoirs or large direct-flow diversions will diminish peak flows to the potential detriment of the endangered fishes. "New" reservoirs in this context includes new tributary reservoirs, as well as enlargements of existing reservoirs or significant changes in the operations of existing reservoirs (e.g., greater frequency or magnitude of releases from storage during base flows with subsequent refill during peak flows). Moreover, storage to augment base flows for fish is no different from the same volume of storage to meet human needs in terms of its impacts on peak flows. The impacts of base flow augmentation on peak flows must be evaluated, weighing the potential benefits to fish due to augmentation against the potential impacts due to peak flow reduction.

The effects of tributary storage on the peak of the Yampa River mainstem would vary with the elevation of the tributary reservoir, its distance upstream from the mainstem and location of the confluence of the tributary on the mainstem. Tributary peak-flow timing differs from that of the mainstem in a predictable way. For example, tributaries that drain low-elevation watersheds in the lower basin generally peak earlier than the Yampa River at Maybell, while high-elevation tributaries in the upper basin may peak after the mainstem. It is the effect of storage on the peak of the mainstem, rather than its effect on the peak of the tributaries, that is critical for the fishes. "Fill and spill" reservoirs on low-elevation tributaries, such as Elkhead Creek, generally impact the ascending limb on the mainstem to a greater degree, while similar headwater reservoirs, such as Steamboat Lake, are more likely to impact the peak and descending limb on the mainstem.

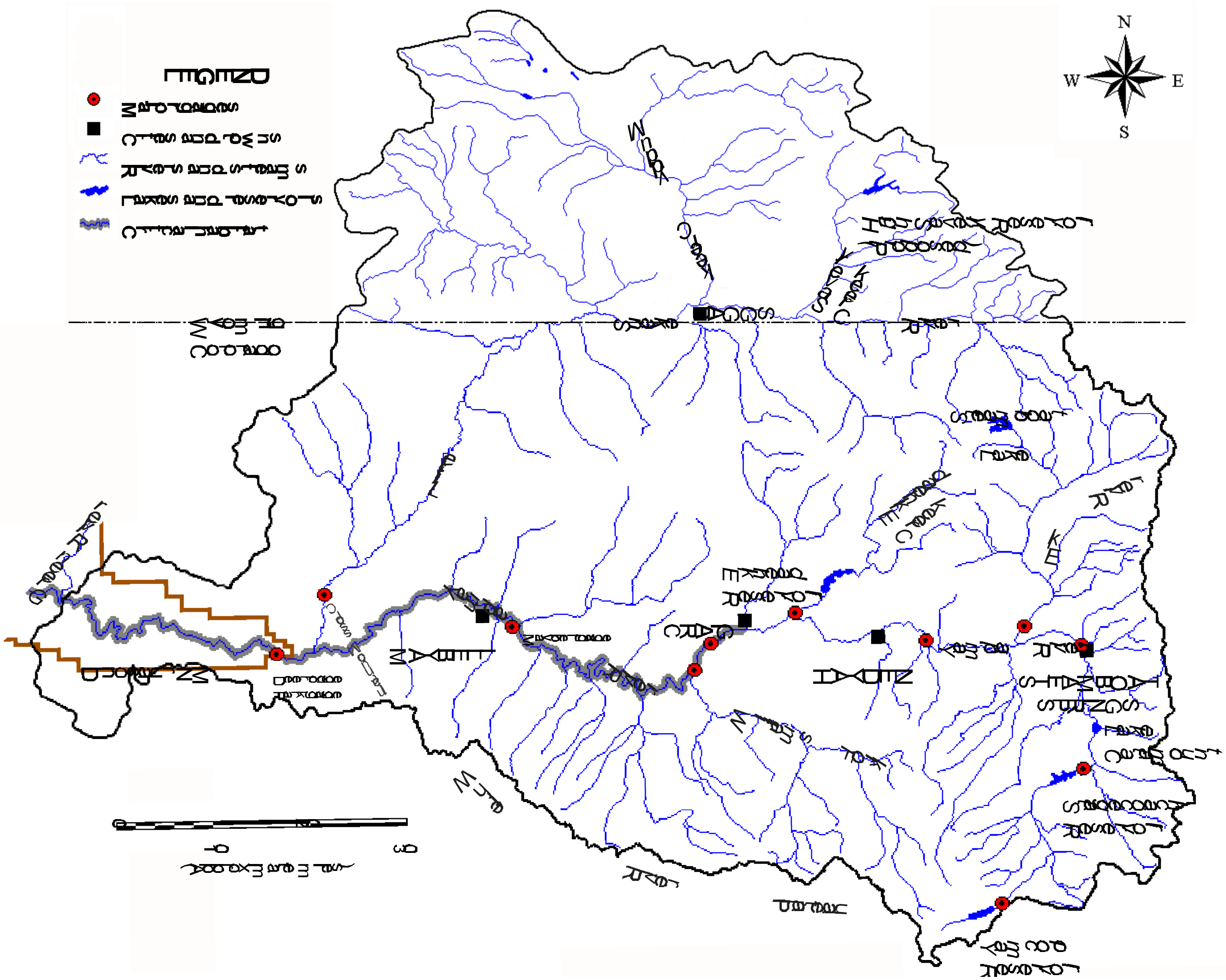

Figure 1. Map of the Yampa River Basin

In contrast to spring flows, August through October typically exhibit the lowest flows of the year. Although the Yampa River has not been impounded by large mainstem dams, naturally low river flows in late summer and early fall are depleted by diversions for agriculture, electric power generation, and municipal and industrial uses. The lowest annual flows at the Maybell gage average 137 cfs between 1916 and 1998. Inter-annual variation also is extremely high. Flows as low as 2 cfs have been recorded in an exceptionally dry year (1934). During 1984, the wettest year of record at the Maybell gage, the Yampa River discharged 2.22 MAF, almost twice the annual average (1.15 MAF). In 1977, the driest year of record at Maybell, the gage measured only 345,000 acre-feet (AF), less than one-third the annual average. However, patterns of precipitation during the year may be at least as important as the total precipitation throughout the year in determining low stream flows. Inadequate rainfall during the irrigation season, even after a normal snowpack, can exacerbate low-flow conditions as natural spring peak flows wane and irrigation demand increases. Conversely, wet conditions during the irrigation season, even after a lower than normal snowpack, can alleviate low-flow conditions.

The Little Snake River is the most significant tributary to the Yampa downstream from Maybell. Although its watershed encompasses roughly half the area upstream from the Deerlodge Park gage on the Yampa River, it contributes only 28% (428,000 AF) of the combined flow. However, it contributes a significant quantity of sediment to the Yampa/Green river complex. This sediment is considered important for building and maintaining spawning bars and nursery habitats for the endangered fishes in Yampa Canyon and the Middle Green River. Although the headwaters of the Little Snake arise in northern Colorado, about 1,331 square miles (35 %) of its watershed lies within the State of Wyoming. All depletions in Wyoming addressed in this plan occur within the Little Snake River subbasin.

Regulatory Background

Endangered Species Act

The Endangered Species Act (ESA) was enacted in 1973 to conserve threatened and endangered species. It requires the U.S. Fish and Wildlife Service (FWS) to consider the status of, and potential threats to, plant and animal species in determining whether it is appropriate to list these species as threatened and endangered. Section 4(a)(1) of the ESA identifies five threat factors, any one of which may determine whether a species is listed as endangered or threatened: (1) present or threatened destruction, modification, or curtailment of its habitat or range; (2) overutilization for commercial, recreational, scientific, or educational purposes; (3) disease or predation; (4) inadequacy of existing regulatory mechanisms; or (5) other natural or manmade factors affecting its continued existence. Section 4(f)(1) requires the FWS to develop and implement "recovery plans" that incorporate "a description of such site-specific management actions as may be necessary to achieve the plan's goal for the conservation and survival of the species; [and] objective, measurable criteria which, when met, would result in a determination....that the species be removed from the list." Such recovery criteria must address the same five threat factors that were considered in listing the species.

The ESA prohibits federal agencies from taking any actions that might jeopardize the continued existence of listed species or adversely modify their designated critical habitats. Section 7 of the ESA outlines procedures for interagency cooperation in conserving federally listed species and their designated critical habitats. Section 7(a)(1) requires federal agencies to carry out programs within their authority to conserve listed endangered and threatened species. Section 7(a)(2) requires these agencies to consult with the FWS whenever actions they authorize, fund or carry out "may affect" listed species. Section 7(b)(4) acknowledges that a federal action may result in "taking" some individuals of listed species incidental to that action, although such incidental take cannot be to the extent that it jeopardizes the continued existence of the species. Nevertheless, Section 9(a)(1) prohibits taking members of any listed species unless such take is incidental to, and not the purpose of, otherwise lawful activities and is within limits specified pursuant to a Section 7 consultation with the FWS for federal activities or permitted pursuant to Section 10 of the ESA for non-federal activities.

Section 9 defines "take" to mean "harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or attempt to engage in any such conduct." "Harm" is further defined as an action that "may include significant habitat modification or degradation where it actually kills or injures wildlife by significantly impairing essential behavioral patterns including breeding, feeding or sheltering." This plan incorporates measures to quantify and minimize incidental take due to entrainment by water diversions in the Yampa Basin.

Application of the ESA in the Upper Colorado River Basin

Pursuant to Section 4(a)(1) of the ESA, the FWS listed four fish species endemic to the Colorado River Basin as endangered: Colorado pikeminnow (*Ptychocheilus lucius*), humpback chub (*Gila cypha*), bonytail (*G. elegans*) and razorback sucker (*Xyrauchen texanus*). These fishes have suffered declining populations throughout their historic range due largely to habitat loss or degradation and introduction of nonnative fish species. Native species evolved under a highly variable hydrologic regime, characterized by seasonally high flows in spring and dramatically lower flows in late summer and fall. Dams constructed throughout the Colorado River Basin have changed free-flowing rivers into a series of lakes and regulated streams, altering the habitats on which these species depend for many of their life requirements. Nonnative species, introduced intentionally or inadvertently, compete with and/or prey upon native species and represent a significant impediment to recovery. Implementation of this plan is intended not only to avoid the likelihood that current and new depletions discussed herein would jeopardize the continued existence of these species or adversely modify their designated critical habitats, but to promote the recovery of these species.

Upper Colorado River Endangered Fish Recovery Program

The ESA encourages interagency cooperation to resolve conflicts between water development and the conservation of listed species. Consistent with this intent, the governors of Wyoming, Colorado and Utah, the Secretary of the Interior, and Administrator of the Western Area Power Administration signed a cooperative agreement in 1988 establishing the Upper Colorado River Endangered Fish Recovery Program in response to concerns within the regulated community that strict enforcement of the ESA in the Upper Colorado River Basin would impact allocation and use of water under existing state laws and interstate compacts. The goal of the Recovery Program is to recover the endangered fishes while providing for certain current and future water development in the Upper Colorado River Basin. The Recovery Program provides a means to address these issues in a coordinated manner and serves as a "reasonable and prudent alternative" as defined by regulation (50 CFR §402.02) to preclude jeopardizing the continued existence of listed species or adversely modifying their critical habitats.

A Section 7 Consultation, Sufficient Progress, and Historic Projects Agreement (Section 7 Agreement) and a Recovery Implementation Program Recovery Action Plan (RIPRAP) were finalized on October 15, 1993. The Section 7 Agreement (Appendix A) refined and clarified the Recovery Program framework for conducting consultations under Section 7 of the ESA on impacts of current and future water depletions in the Upper Basin. It also established procedures to determine if there has been sufficient progress in the recovery of the four listed fishes to enable the Recovery Program to continue to serve as a reasonable and prudent alternative for these depletions. The RIPRAP outlines specific recovery actions, including such measures as acquiring and managing aquatic habitat and water, re-operating existing reservoirs to provide instream flows for fishes, constructing fish passage facilities, controlling nonnative fishes, and propagating and stocking listed fish species. It also stipulates by whom and when these actions would be undertaken and how they would be funded. The RIPRAP has been reviewed and updated annually since 1993.

One such RIPRAP element, under the FY 2002 Green River Action Plan: Yampa and Little Snake Rivers, can be found in subsection I.A.2. to develop a management plan for the Recovery Program in the Yampa Basin. This RIPRAP element calls for: (1) developing and implementing a public involvement plan for the Basin (ongoing), (2) updating estimates of human water needs in the Basin (completed 1998), (3) estimating the low-flow needs of fishes and identifying impediments to fish passage on the Yampa River below Craig (completed 1999), (4) carrying out hydrologic analyses to identify and evaluate flow augmentation needs and strategies (ongoing), (5) installing, operating and maintaining stream gages (ongoing), and (6) developing and implementing an aquatic management plan to reduce nonnative fish impacts, while providing sportfishing opportunities (approved in 1998 and initiated in 1999).

National Environmental Policy Act

The National Environmental Policy Act (NEPA) requires federal agencies to identify and document the impacts of their actions on the human environment. Participation by the FWS in this management plan constitutes such a federal action under the NEPA, which also requires FWS to assess the cumulative environmental impacts, defined by regulation (40 CFR §1508.7) as "the incremental impact of the action when added to other past, present and reasonably foreseeable future actions [emphasis added] regardless of what agency (Federal or non-federal) or person undertakes such other actions." Both the NEPA and ESA limit the assessment of cumulative impacts to actions that are reasonably likely to occur in the foreseeable future, not to include speculative actions.

Neither the Recovery Program nor this management plan were intended to compensate for the impacts of current and potential future depletions on resources other than the four listed endangered fish species or their designated critical habitat. However, we recognize that other resources may be affected by implementing this plan including, but not limited to, other threatened and endangered species, fish and wildlife not listed as threatened or endangered, riparian and riverine habitat, and recreation. For example, maintaining a recreational sport fishery within the Yampa River Basin is considered a high priority for Yampa Basin residents, in spite of the need to remove nonnative sportfish from the river. Moreover, the National Park Service (NPS) has specific mandates that require it to manage Dinosaur National Monument (DNM) to "...leave (it) unimpaired for the enjoyment of future generations."

In conformance with the requirements of the NEPA, the FWS will prepare an environmental assessment (EA) for this management plan to address its potential impacts on these and other resources. Additional NEPA document(s) also may be required for individual actions proposed for implementation in this plan. For example, a separate document will be prepared specifically for augmentation water supply alternatives described elsewhere in this plan. Other recovery actions, such as floodplain acquisition and restoration, have been addressed previously (U.S. Department of the Interior 1998).

Clean Water Act

The Clean Water Act (CWA) is a 1977 amendment to the Federal Water Pollution Control Act of 1972, which established the basic structure to regulate discharges of pollutants into waters of the United States. The section of the CWA most relevant to this discussion is Section 404, which regulates the placement of fill materials, such as those placed in conjunction with the construction of dams and diversions. The 404 program is typically run by the U.S. Army Corps of Engineers (Corps) with oversight from the Environmental Protection Agency. Under the 404 program, a permit must be obtained from the Corps before any fill is placed in the waterway. In many cases, the Corps' issuance of a 404 permit is the federal action that requires non-federal water development projects to comply with both the ESA and NEPA. In such cases, the Corps is the federal "action agency" for the purposes of ESA and NEPA compliance. However, if another federal agency is involved by authorizing, funding and/or constructing a project, that agency may become the lead agency for regulatory compliance activities.

Species Status and Current Distribution

Colorado and Wyoming list other fish species native to the Yampa River Basin as species of special concern: roundtail chub (*G. robusta*), flannelmouth sucker (*Catostomus latipinnis*), bluehead sucker (*C. discobolus*) and Colorado River cutthroat (*Oncorhynchus clarki pleuriticus*). Although these species currently are not protected under the ESA, the first three species share the same or similar habitats to those of the listed species and, like the listed species, face competition and predation by nonnative fish species. Measures included in this Plan to reduce nonnative fish populations likely would benefit the roundtail chub, flannelmouth sucker and bluehead sucker. The cutthroat is found at higher elevations and threatened by competition and hybridization with nonnative trout. Most depletions and all recovery actions would occur downstream from habitats occupied by this species. Therefore, this Plan is expected to be neutral with respect to cutthroat.

Native fishes have been impacted by the proliferation of predatory and competitive nonnative fishes. Young of native fishes are vulnerable to predation by northern pike, smallmouth bass, and channel catfish, reducing survival and recruitment into adult populations. John Hawkins (Colorado State University, Larval Fish Laboratory, personal communication) found evidence of both predation and attempted predation by northern pike on adult Colorado pikeminnow and other species. Even less predatory nonnative species, such as the white sucker, compete with native species for food and space. Therefore, controlling nonnative species is considered essential to the recovery of the endangered fishes and, therefore, is a key element of this plan.

The importance of the Yampa River to the endangered fishes is significant. Razorback sucker and pikeminnow spawn in its lower reaches, which also harbors one of the few remaining populations of humpback chub in the Upper Colorado River Basin. The Yampa also provides critical habitat for adult and subadult Colorado pikeminnow downstream from Craig, Colorado (Figure 1).

Colorado Pikeminnow

The Colorado pikeminnow is endemic to the Colorado River Basin of the southwestern United States. As the largest cyprinid in North America, adult pikeminnow may grow up to 6 feet in length and weigh as much as 80 pounds. Wild, reproducing populations occur in the Green River subbasin, including the Yampa River, and in the Colorado River subbasin of the Upper Colorado River Basin (i.e., above Glen Canyon Dam). Small numbers of wild individuals also exist in the San Juan River subbasin, although their reproduction is limited. The species was extirpated from the Lower Colorado River Basin in the 1970s. Its current distribution in the Green River subbasin is described in Table 1 (Valdez and Ryel 2001a). Geographic distribution of these populations is shown in Figure 2 (Muth et al. 2000).

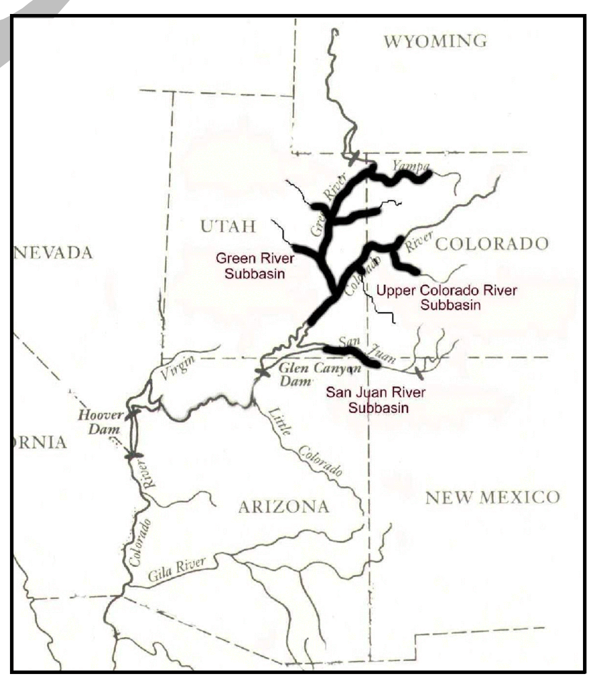

Figure 2. Current distribution of Colorado pikeminnow

Table 1. Distribution of Colorado pikeminnow within the Green River subbasin

River	Occupied Habitat	Limits of Distribution
Green	Lodore Canyon to Colorado River confluence (360 mi.)	Cold water releases from Flaming Gorge Dam have been warmed and species has naturally expanded upstream into Lodore Canyon; species distributed continuously downstream to Colorado River confluence.
Yampa	Craig, CO, to Green River confluence (141 mi.)	Present distribution similar to historic.
Little Snake	Wyoming to Yampa River confluence (50 mi.)	Habitat is marginal; flows are reduced; historic distribution unknown.
White	Taylor Draw Dam to Green River confluence (62 mi.)	Upstream distribution blocked by Taylor Draw Dam.
Price	Lower 89 miles above Green River confluence (89 mi.)	Streamflow reduced; barriers occur above current distribution.
Duchesne	Lower 6 miles above Green River confluence (6 mi.)	Streamflow reduced; barriers occur above current distribution.

The Colorado pikeminnow is a long-distance migrator, moving hundreds of miles to and from spawning areas in canyon regions. Adults utilize pools, deep runs, and eddy habitats maintained by high spring flows. High spring flows maintain channel and habitat diversity, flush sediments from spawning areas, foster food production, form gravel and cobble deposits used for spawning, and rejuvenate backwater nursery habitats. Spawning typically occurs after spring runoff when water temperatures reach 18°C (~64°F) or higher. After hatching, larvae emerge from spawning gravels and drift downstream to nursery backwaters rejuvenated by high spring flows and maintained by relatively stable base flows. Principal threats to the species include streamflow regulation, habitat modification, competition with and predation by nonnative fish species, and pesticides and other pollutants (Valdez and Ryel 2001a).

Humpback Chub

Endemic to the Colorado River Basin of the southwestern United States, this species is restricted to deep, swift, canyon-bound reaches of the Colorado, Green, Yampa and Little Colorado rivers. Six wild populations are known: (1) Black Rocks, Colorado River, Colorado; (2) Westwater Canyon, Colorado River, Utah; (3) Yampa Canyon, Yampa River, Colorado; (4) Desolation/ Gray Canyons, Green River, Utah; (5) Cataract Canyon, Colorado River, Utah; and (6) Colorado and Little Colorado rivers in the Grand Canyon, Arizona. The first five populations are in the Upper Colorado River Basin, while the sixth population is in the Lower Colorado River Basin. Recent population estimates are provided in Table 2. Geographic distribution of the Upper Basin populations is shown in Figure 3 (Valdez and Ryel 2001b).

Table 2. Preliminary population estimates for adult humpback chub in six populations

Population Location	Population Estimate	95% Confidence Intervals	Miles of Estimate	Citation
Upper Basin Recovery Unit				
Black Rocks	1,528	888–2,750	2.3	McAda et al. (1998)
Westwater Canyon	5,186 [1]	not available	8.0	Chart & Lentsch (1999)
Yampa Canyon	600 [2]	not available	45.7	Karp & Tyus (1990)
Desolation/Gray canyons	1,500 [3]	not available	39.0	Chart & Lentsch (2000)
Cataract Canyon	500 [4]	not available	12.0	Valdez (1990)
Lower Basin Recovery Unit				
Little Colorado River	4,508	4,330–4,811	9.3	Douglas & Marsh (1996)
Colorado River	225 [5]	not available	39.1 [5]	Valdez & Ryel (1997)
TOTALS	14,047		155.4	

[1] Sum of three estimates from three disjunct sub-reaches within Westwater Canyon
[2] Estimate by Nesler (Colorado Division of Wildlife) from data provided by Karp & Tyus (1990)
[3] Sum of estimates from data provided by Chart & Lentsch (2000)
[4] Estimate from data provided by Valdez (1990)
[5] Sum of eight aggregations geographically separated from the Little Colorado River confluence

Adults may attain a maximum total length of about 19 inches and weigh up to about 2.5 pounds. Adults utilize eddies and sheltered shoreline habitats maintained by high spring flows. High flows also maintain channel and habitat diversity, flush sediments from spawning areas, increase food production, and form gravel and cobble deposits used for spawning. Spawning occurs on the descending limb of the spring hydrograph at water temperatures greater than 16°C (~61°F). Young typically use low-velocity shoreline habitats, including eddies and backwaters, more prevalent under base flow conditions. Threats to the species include streamflow regulation, habitat modification, predation by nonnative fish species, parasitism, hybridization with other native *Gila* species, and pesticides and other pollutants. Almost 32% of humpback chub historic habitat has been lost due to inundation by reservoirs, cold water releases and flow regulation by dams, and competition and predation by nonnative fishes (Valdez and Ryel 2001b).

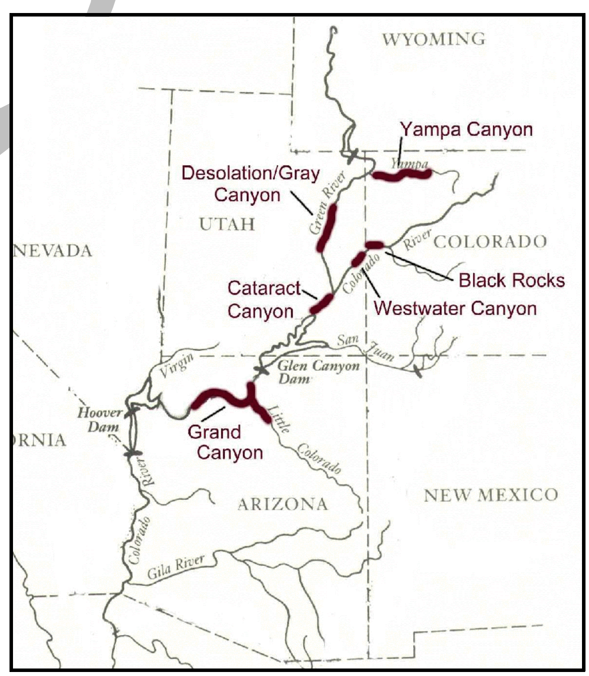

Figure 3. Current distribution of humpback chub

Bonytail

The bonytail is endemic to the Colorado River Basin of the southwestern United States. Adults may reach a maximum size of about 20 inches total length. An unknown number of wild adults exist in Lake Mohave on the mainstem Colorado River of the Lower Colorado River Basin (i.e., below Glen Canyon Dam), and there are small numbers of wild individuals in the Green River and Colorado River subbasins of the Upper Colorado River Basin (Valdez and Ryel 2001c).

The bonytail was historically common to abundant in warm-water reaches of larger rivers from Mexico to Wyoming. Little is known about the specific habitat requirements of bonytail because the species was extirpated from most of its historic range prior to extensive fishery surveys. It is considered to be adapted to mainstem rivers where it has been observed in pools and eddies. Similar to other closely related *Gila* species, bonytail probably spawn in rivers in spring over rocky substrates; spawning has been observed in reservoirs over rocky shoals and shorelines. Based on available distribution data, flooded bottomland habitats probably are important for bonytail growth and conditioning, particularly as nursery habitats for young. Threats to the species include stream flow regulation, habitat modification, predation by introduced nonnative fish species, hybridization with closely related species, and pesticides and other pollutants (Valdez and Ryel 2001c).

Figure 4. Current distribution of bonytail

Currently no self-sustaining populations of bonytail exist in the wild. Wild adult bonytail occur in very low numbers in Lake Mohave in the Lower Colorado River Basin; isolated individuals occur in whitewater canyons of the Upper Colorado River Basin (Figure 4). Only 11 wild adults have been reported recently from the Upper Basin (Valdez et al. 1994). Bonytail were taken from Lake Mohave and transferred to hatcheries to develop broodstock for artificial propagation and subsequent release of progeny into several locations in Upper and Lower basins (Hamman 1981, 1982, 1985). Roughly 130,000 hatchery-produced bonytail were released into Lake Mohave between 1981 and 1987 as part of an effort by the FWS to prevent the extinction of the species and promote its eventual recovery. Survival of bonytail stocked into riverine reaches has been low (Chart and Cranney 1991), and no reproduction or recruitment of stocked fish has been documented. However, recent releases into renovated, predator-free riverside ponds near Parker, Arizona, have produced up to three year-classes (Pacey and Marsh 1998; personal communication, C. Minckley, FWS). Nevertheless, the bonytail is so severely depleted in the wild that activities to prevent its extinction must take priority. Broodstocks for artificial propagation need to be supplemented with wild fish and stocking efforts must continue with the goal of establishing new self-sustaining populations (Valdez and Ryel 2001c). In Colorado, 5,000 fingerling bonytail were stocked in the Green River above Lodore Canyon and 5,000 were stocked in the Yampa River at Echo Park in July 2000 by the Colorado Division of Wildlife (CDOW). In March 2001, CDOW stocked 13,000 fingerling bonytail in the Green River.

Razorback Sucker

The species is endemic to the Colorado River Basin of the southwestern United States. Adults may attain a maximum size of about 40 inches total length and weigh 11-13 pounds. Remaining wild populations are in serious jeopardy. Most individuals that occupy exclusively riverine habitats are now limited to the Upper Colorado River Basin (i.e., above Glen Canyon Dam) where populations are small. The largest riverine population exists in the Middle Green River (Table 3, Figure 5). The largest extant population is found above Davis Dam in Lake Mohave on the mainstem Colorado River of the Lower Colorado River Basin. Small populations also occur above Hoover Dam in Lake Mead on the lower mainstem of the Colorado River (Valdez and Ryel 2001d).

Figure 5. Current distribution of razorback sucker

Table 3. Distribution and abundance of razorback sucker within the Green River subbasin

River	Occupied Habitat/Estimated Abundance	Limits of Distribution
Green	Lodore Canyon to Colorado River confluence (360 mi.); ~524 adults from Yampa River confluence to Duchesne River confluence (Modde et al. 1996).	Cold-water releases from Flaming Gorge Dam previously restricted distribution; warmed releases may allow for range expansion into historic habitat.
Yampa	Craig, CO to Green River confluence (141 mi.); small numbers of wild fish remaining.	Present in low numbers in historic habitat.
White	Taylor Draw Dam to Green River (62 mi.); small numbers of wild fish remaining.	Found in low numbers; distribution upstream blocked by Taylor Draw Dam.
Duchesne	Lower 1.2 mi. above Green River (1.2 mi.); small numbers of wild fish congregate in lower reach in spring.	Found as small aggregations during spring runoff at mouth.

Historically, razorback sucker were widely distributed in warm-water reaches of larger rivers of the Colorado River Basin from Mexico to Wyoming. Riverine habitats used by adults in spring include deep runs, eddies, backwaters, and flooded off-channel environments; in summer, they use runs and pools often in shallow water associated with submerged sandbars; in winter, low-velocity runs, pools, and eddies are preferred. In historic accounts, spring migrations of adult razorback sucker were associated with spawning; a variety of local and long-distance movements and habitat-use patterns have been documented. In rivers razorback spawn on bars of cobble, gravel, and sand substrates during spring runoff at widely ranging flows and water temperatures, typically warmer than 14ºC (~57ºF); razorback also spawn in reservoirs on rocky shoals and shorelines. Young require nursery environments with quiet, warm, shallow water such as tributary mouths, backwaters, or inundated floodplain habitats in rivers, and coves or shorelines in reservoirs. Threats to the species include streamflow regulation, habitat modification, predation by nonnative fish species, and pesticides and other pollutants (Valdez and Ryel 2001d).

Critical Habitat

Pursuant to Section 4(b)(2) of the ESA, on March 21, 1994 (59 FR 13374) the FWS designated critical habitat for the four listed fish species within their historic range in the Yampa River.

Colorado Pikeminnow

Critical habitat includes the Yampa River and its 100-year floodplain from the State Highway 394 bridge in T. 6 N., R. 91 W., section 1 (6th Principal Meridian) to the confluence with the Green River in T. 7 N., R. 103 W., section 28 (6th Principal Meridian). The pikeminnow is a highly mobile, wide-ranging species. Individuals of this population can be found throughout critical habitat in both the Middle Green and Yampa rivers, and occasionally may occur as far upstream as Hayden, Colorado. In spring, Colorado pikeminnow congregate on spawning bars in Yampa Canyon, dispersing on the descending limb of the hydrograph after spawning.

Humpback Chub

Critical habitat includes the Yampa River from the boundary of Dinosaur National Monument (DNM) in T.6 N., R.99W., section 27 (6th Principal Meridian) to the confluence with the Green River in T.7N., R.103W., section 28 (6th Principal Meridian). The Yampa River humpback chub population is less mobile than those of the pikeminnow or razorback sucker, spending its entire life cycle within a relatively narrow home range in DNM from Yampa Canyon downstream to Whirlpool Canyon on the Green River.

Bonytail

Critical habitat includes the Yampa River from the boundary of DNM in T.6N., R.99W., section 27 (6th Principal Meridian) to the confluence with the Green River in T.7N., R.103W., section 28 (6th Principal Meridian). Self-sustaining populations of bonytail are not known to occur in the Yampa River at this time. However, such populations had occurred in both the Yampa and Green rivers in the past.

Razorback Sucker

Critical habitat includes the Yampa River and its 100-year floodplain from the mouth of Cross Mountain Canyon in T. 6 N., R. 98 W., section 23 (6th Principal Meridian) to the confluence with the Green River in T. 7 N., R. 103 W., section 28 (6th Principal Meridian). Razorback suckers generally are found in the Middle Green River between the confluence of the Duchesne and the Yampa. They occupy the lower reaches of Yampa Canyon during spawning and may occur irregularly elsewhere in Yampa Canyon.

Recovery Goals

An endangered species is defined by the ESA as "any species which is in danger of extinction throughout all or a significant portion of its range..." Several factors are used to determine whether a species is listed as endangered:

Genetics: numbers are too low to maintain genetic viability
Demographics: populations are small and declining (deaths exceed births/recruitment)
Population redundancy: populations are too few, scattered or concentrated
Threats: persistent threats are significant

Section 4(a)(1) of the ESA identifies five threat factors, any of which may determine whether a species is listed as endangered or threatened: (1) present or threatened destruction, modification, or curtailment of its habitat or range; (2) overutilization for commercial, recreational, scientific, or educational purposes; (3) disease or predation; (4) inadequacy of existing regulatory mechanisms; or (5) other natural or manmade factors affecting its continued existence. Other natural or manmade factors may include such imminent or potential threats as hybridization with closely related species and contamination with hazardous materials or other pollutants.

Recovery is considered to have been achieved "when management actions and associated tasks (to minimize or remove threats associated with the five listing factors) have been implemented and/or completed to allow genetically and demographically viable, self-sustaining populations to thrive under minimal ongoing management and investment of resources." [emphasis added]

Section 4(c)(2) requires that the status of listed species be reviewed at least once every 4 years to determine if species should be "delisted" (i.e., removed from the list), "downlisted" from endangered to threatened status, or reclassified from threatened to endangered status. Section 4(f)(1) provides for development of "recovery plans" which, among other things, incorporate "objective, measurable criteria which, when met, would result in a determination...that the species be removed from the list."

Valdez and Ryel (2001a-d) have developed such criteria as recovery goals for the four listed fish species in each of two recovery units: (1) Upper Colorado River Basin Recovery Unit, upstream from Glen Canyon Dam, including the San Juan River for Colorado pikeminnow and razorback sucker; (2) Lower Colorado River Basin Recovery Unit, downstream from Glen Canyon Dam. These recovery goals include both demographic criteria (e.g., distribution, population size, mortality and recruitment) and criteria that specifically address the five listing factors of ESA Section 4(a)(1). For each species a minimum viable population (MVP) was determined. The MVP for each species is the minimum number of adults needed to ensure its long-term genetic and demographic viability (Table 4). Table 5 provides a synopsis of demographic criteria for downlisting and delisting.

Table 4. Minimum viable population (MVP) size and adult age of four endangered fishes

	Colorado pikeminnow	Humpback chub	Bonytail	Razorback sucker
Age	7+	4+	4+	4+
MVP	2,600	2,100	4,400	5,800

Table 5. Demographic criteria required to change status of the endangered Colorado River fishes

HUMPBACK CHUB	Latest Adult Population Estimates (Year of estimate)	To Reclassify from “Endangered” to “Threatened” (Downlisting)*	To Remove from Endangered Species List (Delisting)*
Upper Basin	– Black Rocks:1,528 (1998) – Westwater Canyon: 5,186 (1999) – Cataract Canyon: 500 (1990) – Yampa Canyon: 600 (1990) – Desolation/Gray Canyons: 1,500 (2000)	– Each population maintained AND – One core population >2,100*; AND	– Each population maintained AND – Two core populations, each >2,100* AND
Lower Basin	– Grand Canyon: >4,500 (1996-1997)	– One core population >2,100*	– One core population >2,100*
COLORADO PIKEMINNOW	Latest Adult Population Estimates (Year of estimate)	To Reclassify from “Endangered” to “Threatened” (Downlisting)*	To Remove from Endangered Species List (Delisting)*
Upper Basin	– Green River: >2400 (1997) – Upper Colorado River (UCR): 650 (2000) – San Juan River (SJR):<50 (1999)	– Green River and UCR populations maintained AND – Green River core population >2,600*; AND – UCR population >700**; AND – SJR establish 1,000 age-5+ fish**	– Green River and UCR populations maintained AND – Green River core population >2,600*; AND – UCR population >1,000**; **<u>OR</u>** – UCR population >700** and SJR population >800** AND
Lower Basin	– No existing populations	– Reevaluate need for populations and, if needed, maintain (after establishing) two populations, each 2,600*	– Maintain two populations, each >2,600*

** Numbers of fish are based on genetic and demographic viability for each species and refer to adult fish with adequate recruitment. Recovery will be achieved by minimizing or removing threats (e.g.,. controlling nonnative fish, protecting instream flows and developing conservation plans and agreements.)*

*** Numbers of fish are based on inferences about carrying capacity.*

Table 5 continued. Demographic criteria required to change status of the endangered Colorado River fishes

RAZORBACK SUCKER	Latest Adult Population Estimates (Year of estimate)	To Reclassify from "Endangered" to "Threatened" (Downlisting)*	To Remove from Endangered Species List (Delisting)*
Upper Basin	– Green River: ~ 520 (1996) – Upper Colorado River (UCR): few – San Juan River (SJR): few	– Maintain (after establishing) populations in Green River and **<u>EITHER</u>** UCR or SJR, each >5,800*; AND	– Maintain populations in Green River and **<u>EITHER</u>** UCR or SJR, each population >5,800*; AND
Lower Basin	– Lake Mojave: <10,000 (1999) – Lake Mead: ~ 400 (1999) – Verde River: <100 (1993)	– Maintain "genetic refuge"*** in Lake Mohave; AND – Maintain two populations, each >5,800*	– Maintain genetic refuge*** in Lake Mohave; AND – Maintain two populations, each >5,800*
BONYTAIL	Latest Adult Population Estimates (Year of estimate)	To Reclassify from "Endangered" to "Threatened" (Downlisting)*	To Remove from Endangered Species List (Delisting)*
Upper Basin	– Few wild bonytail exist	– Maintain (after establishing) populations in Green River and UCR, each >4,400*; AND	– Maintain populations in Green River and UCR, each >4,400*; AND
Lower Basin	– Few wild bonytail exist	– Maintain (after establishing) genetic refuge*** in suitable location; AND – Maintain (after establishing) two populations, each >4,400*	– Maintain genetic refuge*** in a suitable location AND – Maintain two populations, each >4,400*

** Numbers of fish are based on genetic and demographic viability for each species and refer to adult fish with adequate recruitment. Recovery will be achieved by minimizing or removing threats (e.g.,. controlling nonnative fish, protecting instream flows and developing conservation plans and agreements.)*

*** Numbers of fish are based on inferences about carrying capacity.*

****A "genetic refuge" is a group of fish that, as a whole, represent a substantial portion of the genetic variability of the species (50,000 fish is the estimated number for the Lake Mohave genetic refuge).*

Colorado Pikeminnow

Recovery criteria

The recovery goals address recovery of the Colorado pikeminnow only in the Upper Colorado River Basin (above Glen Canyon Dam, including the San Juan River subbasin). The need for self-sustaining populations in the Lower Basin and associated site-specific management actions/tasks necessary to minimize or remove threats will be evaluated at the status review of the species, which is conducted at least once every 4 years. The Colorado pikeminnow was listed by the FWS prior to adoption of a distinct population segment (DPS) policy in 1996. If Lower Basin populations are determined to be necessary for recovery, the FWS intends to conduct a DPS analysis on the Colorado pikeminnow at the first opportunity (i.e., when recommendations are made to change the listing status of the species, or at the status review of the species). If this analysis determines that Lower/Upper Basin DPS designations are warranted, these recovery criteria will be reevaluated and modified, if necessary. Although the best available scientific information was used to develop these recovery goals, uncertainties remain, and improved understanding of Colorado pikeminnow biology may prompt revision of these recovery goals in the future.

Downlisting can occur if, during a 4-year period, the upper basin metapopulation is maintained such that: (1) a genetically and demographically viable, self-sustaining population is maintained in the Green River subbasin such that (a) the trends in separate adult (age 7+) point estimates for the middle Green River and the Lower Green River do not decline significantly, and (b) mean estimated recruitment of age-5 and age-6 naturally produced fish equals or exceeds adult mortality for the Green River subbasin, and (c) each population point estimate for the Green River subbasin exceeds the MVP of 2,600 adults; and (2) a self-sustaining population of at least 700 adults (number based on inferences about carrying capacity) is maintained in the upper Colorado River subbasin such that (a) the trend in adult point estimates does not decline significantly, and (b) mean estimated recruitment of age-5 and age-6 naturally produced fish equals or exceeds adult mortality; and (3) a target number of 1,000 age-5+ fish (number based on estimated survival of stocked fish and inferences about carrying capacity) is established through augmentation and/or natural reproduction in the San Juan River subbasin; and (4) when certain site-specific management tasks to minimize or remove threats have been identified, developed, implemented, evaluated, and/or revised.

Delisting can occur if, during a 7-year period beyond downlisting, the Upper Basin metapopulation is maintained such that: (1) a genetically and demographically viable, self-sustaining population is maintained in the Green River subbasin such that (a) the trends in separate adult point estimates for the Middle Green River and the Lower Green River do not decline significantly, and (b) mean estimated recruitment of age-5 and age-6 naturally produced fish equals or exceeds adult mortality for the Green River subbasin, and (c) each population point estimate for the Green River subbasin exceeds 2,600 adults; and (2) either the upper Colorado River subbasin self-sustaining population exceeds 1,000 adults **OR** the Upper Colorado River subbasin self-sustaining population exceeds 700 adults and San Juan River subbasin population is self-sustaining and exceeds 800 adults (numbers based on inferences about carrying capacity) such that for each population (a) the trend in adult point estimates does not decline significantly, and (b) mean estimated recruitment of age-5 and age-6 naturally produced fish equals or exceeds adult mortality; and (3) when certain site-specific management tasks to minimize or remove threats have been implemented and/or completed and necessary levels of protection are attained.

Conservation plans will go into effect at delisting to provide for long-term management and protection of the species, and to provide reasonable assurances that recovered Colorado pikeminnow populations will be maintained without the need for relisting. Elements of those plans could include (but are not limited to) provision of flows for maintenance of habitat conditions required for all life stages, regulation and/or control of nonnative fishes, minimization of the risk of hazardous-materials spills, and monitoring of populations and habitats. Signed agreements among State agencies, Federal agencies, Native American tribes, and other interested parties must be in place to implement the conservation plans before delisting can occur.

Management actions needed

Management actions in **bold typeface** are relevant to Yampa River fishes. **Underlined** management actions are addressed, at least in part, in this plan.

1. **Provide and legally protect habitat (including flow regimes necessary to restore and maintain required environmental conditions) necessary to provide adequate habitat and sufficient range for all life stages to support recovered populations.**
2. **Provide passage over barriers within occupied habitat to allow adequate movement and, potentially, range expansion.**
3. Investigate options to provide appropriate water temperatures in the Gunnison River.
4. **Minimize entrainment of subadults and adults in diversion canals.**
5. **Ensure adequate protection from overutilization.**
6. **Ensure adequate protection from diseases and parasites.**
7. **Regulate nonnative fish releases and escapement into the main river, floodplain, and tributaries.**
8. **Control problematic nonnative fishes as needed.**
9. **Minimize the risk of hazardous-materials spills in critical habitat.**
10. **Remediate water-quality problems.**
11. **Provide for the long-term management and protection of populations and their habitats beyond delisting (i.e., conservation plans).**

Estimated time to achieve recovery

Reliable population estimates, based on a multiple mark-recapture model, are needed for all populations during a 4-year monitoring period for downlisting and during a 7-year monitoring period beyond downlisting in order to achieve delisting. The accuracy and precision of each point estimate will be assessed by the FWS in cooperation with the respective recovery or conservation programs, and in consultation with investigators conducting the point estimates and with qualified statisticians and population ecologists. First reliable point estimates are expected for all populations by 2001. If these estimates are acceptable to the FWS and all recovery criteria are met, downlisting could be proposed in 2006 and delisting could be proposed in 2013 (Figure 6). This estimated timeframe is based on current understanding of the status and trends of populations and on the monitoring time required to meet the downlisting and delisting criteria.

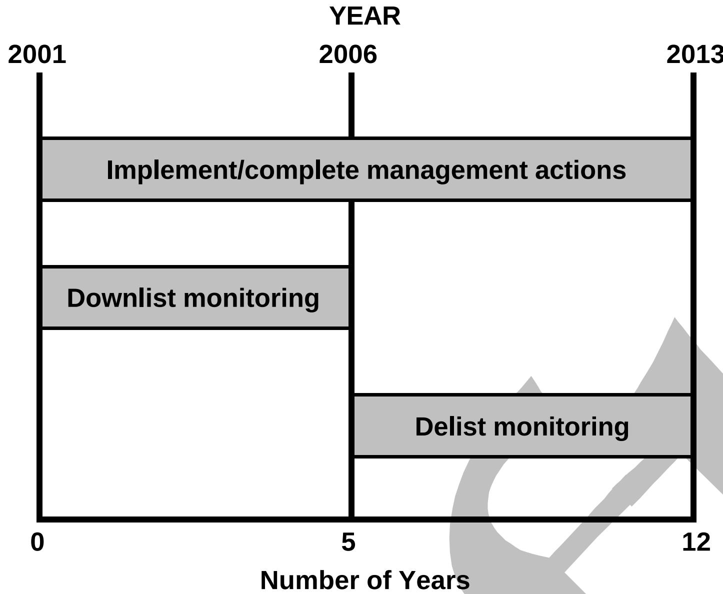

Figure 6. Estimated time to achieve recovery of the Colorado pikeminnow

Humpback Chub

Recovery criteria

Objective, measurable criteria for recovery of humpback chub in the Colorado River Basin are presented for each of two recovery units (i.e., the Upper Basin, including the Green River and Upper Colorado River subbasins, and Grand Canyon in the Lower Basin) because of different recovery programs and to address unique threats and site-specific management actions/tasks necessary to minimize or remove those threats. Recovery of the species is currently considered across the Upper and Lower basins because of the present status of populations and existing information on humpback chub biology.

The humpback chub was listed by the FWS prior to adoption of a distinct population segment (DPS) policy in 1996. The FWS intends to conduct a DPS analysis on the humpback chub at the first opportunity (i.e., when recommendations are made to change the listing status of the species, or at the status review of the species). If this analysis determines that Lower/Upper Basin DPS designations are warranted, these recovery criteria will need to be reevaluated and modified, if necessary. Although the best available scientific information was used in developing these recovery goals, uncertainties remain, and improved understanding of humpback chub biology may prompt revision of these recovery goals in the future.

Downlisting can occur if, during a 4-year period: (1) the trend in adult (age-4+) point estimates for each of the six extant populations does not decline significantly; and (2) mean estimated recruitment of age-3 naturally produced fish equals or exceeds adult mortality for each of the six extant populations; and (3) two genetically and demographically viable, self-sustaining core populations are maintained, such that each point estimate for each core population exceeds the MVP of 2,100 adults; and (4) when certain site-specific management tasks to minimize or remove threats have been identified, developed, implemented, evaluated, and/or revised.

Delisting can occur if, during a 3-year period beyond downlisting: (1) the trend in adult point estimates for each of the six extant populations does not decline significantly; and (2) mean estimated recruitment of age-3 naturally produced fish equals or exceeds adult mortality for each of the six extant populations; and (3) three genetically and demographically viable, self-sustaining core populations are maintained, such that each point estimate for each core population exceeds 2,100 adults; and (4) when certain site-specific management tasks to minimize or remove threats have been implemented and/or completed and necessary levels of protection are attained.

Conservation plans will go into effect at delisting to provide for long-term management and protection of the species, and to provide reasonable assurances that recovered humpback chub populations will be maintained without the need for relisting. Elements of those plans could include (but are not limited to) provision of flows for maintenance of habitat conditions required for all life stages, regulation and/or control of nonnative fishes, minimization of the risk of hazardous-materials spills, and monitoring of populations and habitats. Signed agreements among State agencies, Federal agencies, Native American tribes, and other interested parties must be in place to implement the conservation plans before delisting can occur.

Management actions needed

Management actions in **bold typeface** are relevant to Yampa River fishes. **Underlined** management actions are addressed, at least in part, in this plan.

1. **Provide and legally protect habitat (including flow regimes necessary to restore and maintain required environmental conditions) necessary to provide adequate habitat and sufficient range for all life stages to support recovered populations.**
2. Investigate the role of the mainstem Colorado River in maintaining the Grand Canyon population.
3. Investigate the anticipated effects of and options for providing warmer water temperatures in the mainstem Colorado River through Grand Canyon.
4. **Ensure adequate protection from overutilization.**
5. **Ensure adequate protection from diseases and parasites.**
6. **Regulate nonnative fish releases and escapement into the main river, floodplain, and tributaries.**
7. **Control problematic nonnative fishes as needed.**
7. **Minimize the risk of increased hybridization among *Gila* spp.**
8. **Minimize the risk of hazardous-materials spills in critical habitat.**
9. **Provide for the long-term management and protection of populations and their habitats beyond delisting (i.e., conservation plans).**

Estimated time to achieve recovery

Reliable population estimates, based on a multiple mark-recapture model, are needed for all six extant populations during a 4-year monitoring period for downlisting and during a 3-year monitoring period beyond downlisting to achieve delisting. Accuracy and precision of each point estimate will be assessed by the FWS in cooperation with the respective recovery or conservation programs, and in consultation with investigators conducting point estimates and with qualified statisticians and population ecologists. First reliable point estimates are expected for all populations by 2002. If these estimates are acceptable to the FWS and all recovery criteria are met, downlisting could be proposed in 2007 and delisting could be proposed in 2010 (Figure 7). This estimated timeframe is based on current understanding of the status and trends of populations and on the monitoring time required to meet the downlisting and delisting criteria.

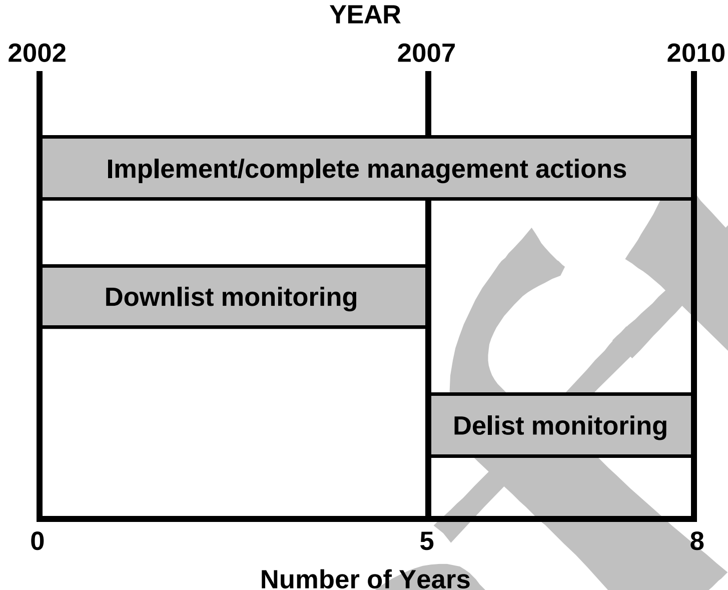

Figure 7. Estimated time to achieve recovery of the humpback chub

Bonytail

Recovery criteria

Objective, measurable criteria for recovery of bonytail in the Colorado River Basin are presented below for each of two recovery units (i.e., the Upper Basin, including the Green River and Upper Colorado River subbasins, and the Lower Basin) because of different recovery programs and to address unique threats and site-specific management actions/tasks necessary to minimize or remove those threats. Recovery of the species is currently considered across the Upper and Lower basins because of the present status of populations and existing information on bonytail biology. Self-sustaining populations will need to be established through augmentation. Without viable wild populations, there are many uncertainties associated with recovery of bonytail. These recovery criteria will need to be reevaluated and revised after self-sustaining populations are established and there is improved understanding of bonytail biology.

The bonytail was listed by FWS prior to adoption of a distinct population segment (DPS) policy in 1996. The FWS intends to conduct a DPS analysis on the bonytail at the first opportunity (i.e., when recommendations are made to change the listing status of the species, or at the status review of the species). If this analysis determines that Lower/Upper Basin DPS designations are warranted, these recovery criteria will need to be reevaluated and modified, if necessary.

Downlisting can occur if, during a 4-year period: (1) genetically and demographically viable, self-sustaining populations are maintained in the Green River subbasin and Upper Colorado River subbasin such that (a) the trend in adult (age-4+) point estimates for each of the two populations does not decline significantly, and (b) mean estimated recruitment of age-3 fish equals or exceeds adult mortality for each of the two populations, and (c) point estimates for each of the two populations exceed the MVP of 4,400 adults; and (2) a genetic refuge is maintained in a suitable location (e.g., Lake Mohave, Lake Havasu) in the Lower Basin recovery unit; and (3) two genetically and demographically viable, self-sustaining populations are maintained in the Lower Basin recovery unit (mainstem and/or tributaries) such that (a) the trend in adult point estimates for each population does not decline significantly, and (b) mean estimated recruitment of age-3 fish equals or exceeds adult mortality for each population, and (c) the point estimates for each population exceed 4,400 adults; and (4) when certain site-specific management tasks to minimize or remove threats have been identified, developed, implemented, evaluated, and/or revised.

Delisting can occur if, during a 3-year period beyond downlisting: (1) genetically and demographically viable, self-sustaining populations are maintained in the Green River subbasin and upper Colorado River subbasin such that (a) the trend in adult point estimates for each of the two populations does not decline significantly, and (b) mean estimated recruitment of age-3 fish equals or exceeds adult mortality for each of the two populations, and (c) each point estimate for each of the two populations exceeds 4,400 adults; and (2) a genetic refuge is maintained in the lower basin recovery unit; and (3) two genetically and demographically viable, self-sustaining populations are maintained in the Lower Basin recovery unit such that (a) the trend in adult point estimates for each population does not decline significantly, and (b) mean estimated recruitment of age-3 fish equals or exceeds adult mortality for each population, and (c) each point estimate for each population exceeds 4,400 adults; and (4) when certain site-specific management tasks to minimize or remove threats have been implemented and/or completed and necessary levels of protection are attained.

Conservation plans will go into effect at delisting to provide for long-term management and protection of the species, and to provide reasonable assurances that recovered bonytail populations will be maintained without the need for relisting. Elements of those plans could include (but are not limited to) provision of flows for maintenance of habitat conditions required for all life stages, regulation and/or control of nonnative fishes, minimization of the risk of hazardous-materials spills, and monitoring of populations and habitats. Signed agreements among State agencies, Federal agencies, Native American tribes, and other interested parties must be in place to implement the conservation plans before delisting can occur.

Management actions needed

Management actions in **bold typeface** are relevant to Yampa River fishes. **Underlined** management actions are addressed, at least in part, in this plan.

1. **Reestablish populations with hatchery-produced fish.**
2. Identify genetic variability of bonytail and maintain a genetic refuge in a suitable location in the lower basin.
3. **Provide and legally protect habitat (including flow regimes necessary to restore and maintain required environmental conditions) necessary to provide adequate habitat and sufficient range for all life stages to support recovered populations.**
4. Provide passage over barriers within occupied habitat to allow unimpeded movement and, potentially, range expansion.
5. Investigate options to provide appropriate water temperatures in the Gunnison River.
6. Minimize entrainment of subadults and adults at diversion/out-take structures.

7. **Investigate habitat requirements for all life stages and provide those habitats.**
8. **Ensure adequate protection from overutilization.**
9. **Ensure adequate protection from diseases and parasites.**
10. **Regulate nonnative fish releases and escapement into the main river, floodplain, and tributaries.**
11. **Control problematic nonnative fishes as needed.**
12. **Minimize the risk of increased hybridization among *Gila* spp.**
13. **Minimize the risk of hazardous-materials spills in critical habitat.**
14. **Remediate water-quality problems.**
15. **Provide for the long-term management and protection of populations and their habitats beyond delisting (i.e., conservation plans).**

Estimated time to achieve recovery

Time to achieve recovery of the bonytail cannot be accurately determined until self-sustaining populations are established through augmentation and habitat enhancement. Reliable population estimates, based on a multiple mark-recapture model, are needed for all populations during a 5-year monitoring period for downlisting and during a 3-year monitoring period beyond downlisting to achieve delisting. The accuracy and precision of each point estimate will be assessed by the FWS in cooperation with the respective recovery or conservation programs, and in consultation with investigators conducting the point estimates and with qualified statisticians and population ecologists. Self-sustaining populations and first reliable point estimates for all populations are expected by 2015. If these estimates are acceptable to the FWS and all recovery criteria are met, downlisting could be proposed in 2020 and delisting could be proposed in 2023 (Figure 8).

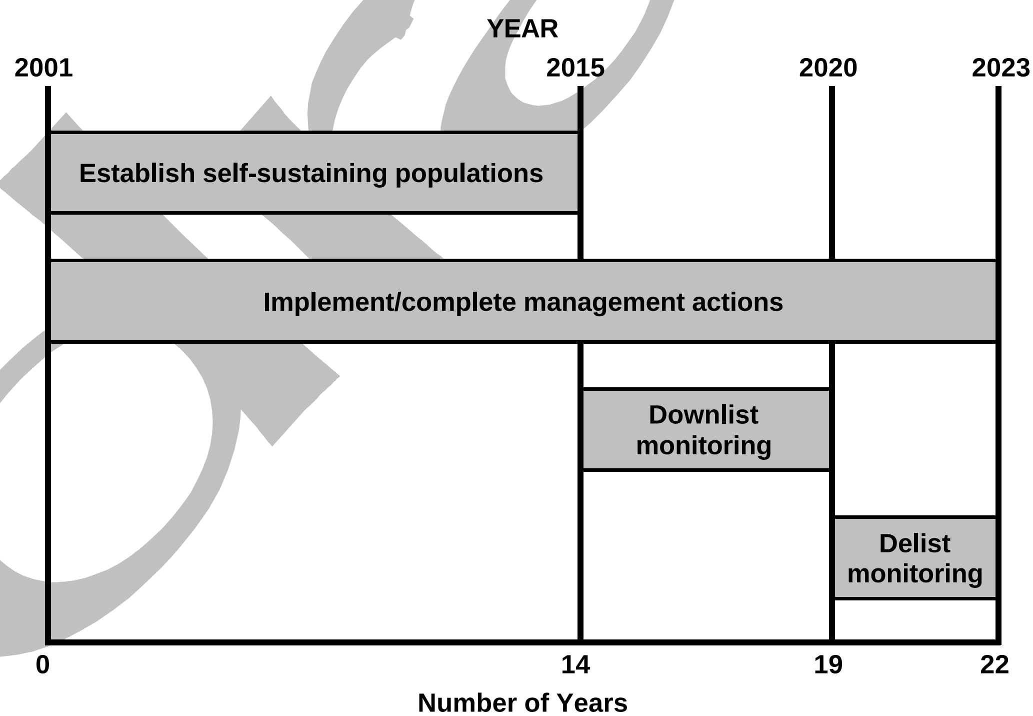

Figure 8. Estimated time to achieve recovery of the bonytail

Razorback Sucker

<u>Recovery criteria</u>

Objective, measurable criteria for recovery of razorback sucker in the Colorado River Basin are presented for each of two recovery units (i.e., the Upper Basin, including the Green River, Upper Colorado River, and San Juan River subbasins, and Lower Basin) because of different recovery programs and to address unique threats and site-specific management actions/tasks necessary to minimize or remove those threats. Recovery of the species is currently considered across the Upper and Lower basins because of the present status of populations and existing information on razorback sucker biology. Self-sustaining populations will need to be established through augmentation. Without viable wild populations, there are many uncertainties associated with recovery of razorback sucker. These recovery criteria will need to be reevaluated and revised after self-sustaining populations are established and there is improved understanding of razorback sucker biology. The razorback sucker was listed by the FWS prior to adoption of a distinct population segment (DPS) policy in 1996. The FWS intends to conduct a DPS analysis on the razorback sucker at the first opportunity (i.e., when recommendations are made to change the listing status of the species, or at the status review of the species). If this analysis determines that Lower/Upper Basin DPS designations are warranted, these recovery criteria will need to be reevaluated and modified, if necessary.

<u>Downlisting</u> can occur if, during a 4-year period: (1) genetically and demographically viable, self-sustaining populations are maintained in the Green River subbasin and **EITHER** in the Upper Colorado River subbasin or the San Juan River subbasin such that (a) the trend in adult (age-4+) point estimates for each of the two populations does not decline significantly, (b) mean estimated recruitment of age-3 fish equals or exceeds adult mortality for each of the two populations, and (c) each point estimate for each of the two populations exceeds the MVP of 5,800 adults; and (2) a genetic refuge is maintained in Lake Mohave of the Lower Basin recovery unit; and (3) two genetically and demographically viable, self-sustaining populations are maintained in the lower basin recovery unit (mainstem and/or tributaries) such that (a) the trend in adult point estimates for each population does not decline significantly, (b) mean estimated recruitment of age-3 fish equals or exceeds adult mortality for each population, (c) point estimates for each population exceed 5,800 adults; and (4) when certain site-specific management tasks to minimize or remove threats have been identified, developed, implemented, evaluated, and/or revised.

<u>Delisting</u> can occur if, during a 3-year period beyond downlisting: (1) genetically and demographically viable, self-sustaining populations are maintained in the Green River subbasin and **EITHER** in the upper Colorado River subbasin or the San Juan River subbasin such that (a) the trend in adult point estimates for each of the two populations does not decline significantly,(b) mean estimated recruitment of age-3 fish equals or exceeds adult mortality for each of the two populations, and (c) each point estimate for each of the two populations exceeds 5,800 adults; and (2) a genetic refuge is maintained in Lake Mohave; and (3) two genetically and demographically viable, self-sustaining populations are maintained in the lower basin recovery unit such that (a) the trend in adult point estimates for each population does not decline significantly, (b) mean estimated recruitment of age-3 fish equals or exceeds adult mortality for each population, and (c) each point estimate for each population exceeds 5,800 adults; and (4) when certain site-specific management tasks to minimize or remove threats have been implemented and/or completed and necessary levels of protection are attained.

Conservation plans will go into effect at delisting to provide for long-term management and protection of the species, and to provide reasonable assurances that recovered razorback sucker populations will be maintained without the need for relisting. Elements of those plans could include (but are not limited to) provision of flows for maintenance of habitat conditions required for all life stages, regulation and/or control of nonnative fishes, minimization of the risk of hazardous-materials spills, and monitoring of populations and habitats. Signed agreements among State agencies, Federal agencies, Native American tribes, and other interested parties must be in place to implement the conservation plans before delisting can occur.

<u>Management actions needed</u>

Management actions in **bold typeface** are relevant to Yampa River fishes. **<u>Underlined</u>** management actions are addressed, at least in part, in this plan.

1. Reestablish populations with hatchery-produced fish.
2. Identify and maintain genetic variability of razorback sucker in Lake Mohave.
3. **<u>Provide and legally protect habitat (including flow regimes necessary to restore and maintain required environmental conditions) necessary to provide adequate habitat and sufficient range for all life stages to support recovered populations.</u>**
4. Provide passage over barriers within occupied habitat to allow unimpeded movement and, potentially, range expansion.
5. Investigate options to provide appropriate water temperatures in the Gunnison River.
6. Minimize entrainment of subadults and adults at diversion/out-take structures.
7. **<u>Ensure adequate protection from overutilization.</u>**
8. **Ensure adequate protection from diseases and parasites.**
9. **<u>Regulate nonnative fish releases and escapement into the main river, floodplain, and tributaries.</u>**
10. **<u>Control problematic nonnative fishes as needed.</u>**
11. **Minimize the risk of hazardous-materials spills in critical habitat.**
12. **Remediate water-quality problems.**
13. Minimize the threat of hybridization with white sucker.
14. **<u>Provide for the long-term management and protection of populations and their habitats beyond delisting (i.e., conservation plans).</u>**

<u>Estimated time to achieve recovery</u>

Time to achieve recovery of the razorback sucker cannot be accurately estimated until self-sustaining populations are established through augmentation and habitat enhancement. Reliable population estimates, based on a multiple mark-recapture model, are needed for all populations during a 4-year monitoring period for downlisting and during a 3-year monitoring period beyond downlisting in order to achieve delisting. The accuracy and precision of each point estimate will be assessed by the FWS in cooperation with the respective recovery or conservation programs, and in consultation with investigators conducting the point estimates and with qualified statisticians and population ecologists. Self-sustaining populations and first reliable point estimates for all populations are expected by 2015. If these estimates are acceptable to the FWS and all recovery criteria are met, downlisting could be proposed in 2020 and delisting could be proposed in 2023 (Figure 9).

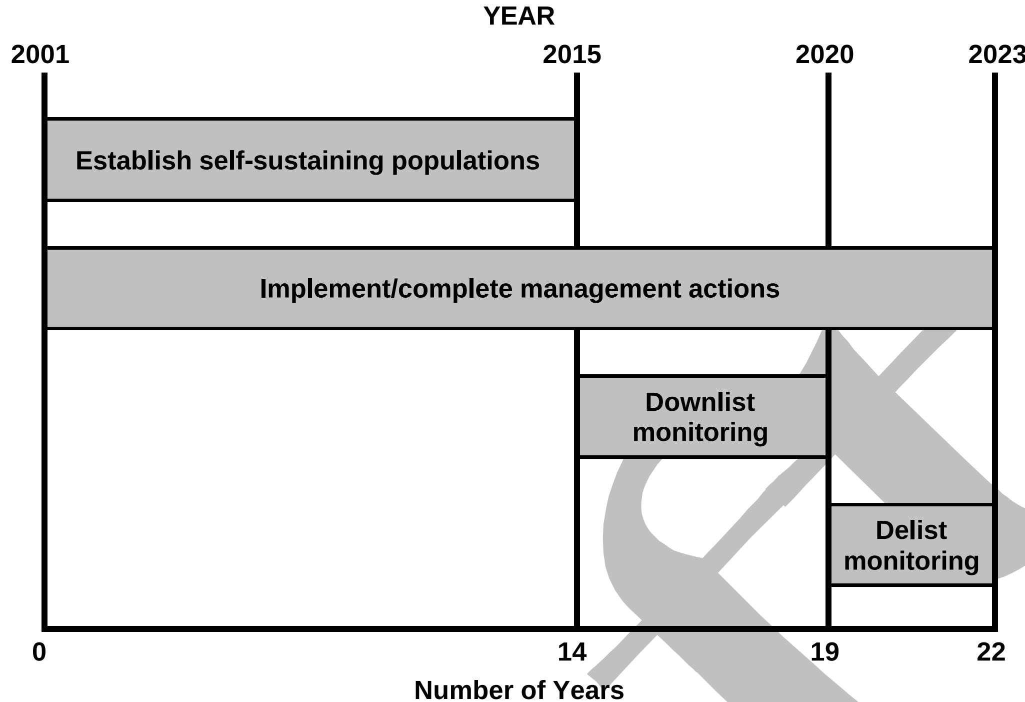

Figure 9. Estimated time to achieve recovery of the razorback sucker

Water Rights Administration

With the exception of certain tributaries and the Yampa River upstream from the town of Yampa, most water rights in the Yampa River Basin have enjoyed freedom from strict administration by the Colorado State Engineer. Similarly, water users in the Wyoming portion of the Basin (e.g., the Little Snake River Basin and its tributaries) have generally not experienced regulation and curtailment of uses by water administration officials of the Wyoming Board of Control. The water users of the Basin desire to continue this practice. Although no one can guarantee that water rights will not be strictly administered in the Basin in the future, this plan neither requires nor precludes such administration nor will it interfere in any way with exercising water rights in the Yampa Basin consistent with relevant state and federal law, including interstate compacts.

The Recovery Program currently augments natural flows in the Yampa River by releasing up to 2,000 AF per year from Steamboat Lake under the terms of a lease between the FWS and the Colorado Division of Parks and Outdoor Recreation (CDPOR). At present, 3,300 AF has been adjudicated for instream use and must be subleased to the State of Colorado for that purpose. The Colorado State Engineer shepherds contract deliveries such as this, less any transit losses, using available streamflow gages to track its progress from its point of release to its point of delivery. However, in accordance with Colorado water law, the underlying natural flow of the river may be diverted in priority. For example, if the natural river flow of 20 cfs were augmented by 50 cfs (a combined flow of 70 cfs), water users would be entitled to take the 20 cfs as long as there were no senior calls on the water downstream that would require junior water users to leave the water in the river.

Moreover, under certain conditions, carriage of augmentation flows might allow water users to take water that otherwise might be physically unavailable to them. For example, if a water user is entitled to divert 10 cfs from the river, but can do so only when the flows exceed 30 cfs, that user would be unable to divert water if flows were 20 cfs. However, if flows were augmented by 50 cfs to 70 cfs, as in the example above, the water user would be able to divert 10 cfs, reducing river flows at that point to 60 cfs and thereby diminishing the net benefit of the augmentation release by 10 cfs. Although return flows may restore a portion of the diverted flow, if this effect were compounded by a series of intervening diversions, the only water left in the river could be what is released for augmentation. For the endangered fishes to enjoy the full benefit from flow augmentation, intervening water users would have to agree not to divert water from the river that otherwise would have been unavailable to them without the carriage flows from augmentation deliveries. Such forbearance agreements would provide greater certainty of achieving flow targets for the fish and allow for more efficient use of limited augmentation water supplies.

This plan does not rely upon nor preclude instream flow rights to serve the flow needs of fishes. In 1999, the State of Colorado withdrew its 1995 applications for instream flow water rights on the Yampa River and has no immediate plans to re-apply. Without such a water right, the State cannot place a call on the river to serve the flow needs of the fishes. However, the State may deliver water from storage for this purpose, as it has done in the past using water leased from Steamboat Lake. Moreover, this plan does not preclude the State from filing for instream flow rights in the future. Moreover, the Recovery Program periodically will review the need to incorporate such flow filings into the RIPRAP (see subsection entitled Instream flow water rights).

Geographic Scope

Although critical habitat for these species is located downstream from Craig, Colorado, the flow of the Yampa River within critical habitat is depleted by diversions from the Yampa River and its tributaries upstream from critical habitat, as well as by those within the critical habitat reach. Therefore, this plan encompasses depletions from the entire Yampa River Basin, including the Little Snake River, in Colorado and Wyoming. Moreover, the Middle Green River is ecologically inseparable from the Lower Yampa in that the Green River not only benefits from the flows of the Yampa River, but also benefits the Yampa River populations of the endangered fishes by providing them important nursery habitats from which fish are recruited as sub-adults into the Yampa River. Therefore, overall recovery actions, not limited to this Plan, will focus on critical habitat reaches of both the Yampa and Middle Green rivers. The Middle Green River extends from the confluence of the Yampa River downstream to the confluence of the White River near Ouray, Utah.

Flaming Gorge Dam, located on the Green River 65 rivermiles upstream from the confluence of the Yampa, exerts a profound influence on the Green River both upstream and downstream from the Yampa. The U.S. Bureau of Reclamation (USBR) has operated the dam primarily for irrigation water supply and power generation since 1964, when the dam was completed. Its principal influence on the river is to diminish spring peak flows, while increasing base flows during the remainder of the year. Nevertheless, the Green River downstream from the Yampa confluence is the product of both river systems. Therefore, for the Middle Green River, this plan recognizes both the impacts and opportunities for flow management afforded by Flaming Gorge Dam. However, this plan is not intended to, nor will it, mitigate the impacts of the dam on endangered fishes. Water can be released from Flaming Gorge to reinforce or extend the peak flow of the Green River below the Yampa confluence. By increasing base flows, the dam partially offsets impacts to the Green River due to depletions from the Yampa. However, the dam cannot mitigate depletion impacts to the Yampa River itself. Moreover, the dam has only limited capacity for controlled releases through the hydropower penstocks and bypass tubes. Re-operation of Flaming Gorge Dam to mitigate its impacts on the endangered fishes and support their recovery will be addressed in a separate biological opinion and is not part of this Plan.

The recovery actions in this Plan will address impacts on the Middle Green/Lower Yampa River populations of Colorado pikeminnow and razorback sucker, Yampa Canyon population of humpback chub, and Yampa Canyon population of bonytail (if successfully reintroduced). Figures 2-5 display the current distribution of existing populations of Colorado pikeminnow, humpback chub and razorback sucker in the Yampa and Middle Green rivers, and those sites on the Yampa and Green rivers in Colorado where the CDOW recently reintroduced the bonytail. Depletions from the Yampa River could impact these populations. This plan addresses impacts due to water depletions from the Yampa River and its tributaries, as well as competition and predation by nonnative fishes and other non-depletive impacts on these species and their habitats. This Plan does not address the impacts of depletions from the Green River mainstem or any of its tributaries other than the Yampa.

DESCRIPTION OF THE PROPOSED ACTION

Historic, Current and Projected Future Depletions

This plan is intended to offset the impacts of both current and all foreseeable future depletions from the Yampa River and its tributaries in Colorado and Wyoming. This Plan encompasses new depletions due to direct flow diversions and small tributary reservoirs, as well as increased use of existing reservoir storage. Although future depletions are quantified below by sector and geographic area, this plan does not limit depletions to those sectors/areas nor preclude greater or lesser depletions from occurring in any sector or area, provided that the aggregate of depletions is less than the increments of depletions as defined below. However, it is not intended to, nor does it, cover new large mainstem dams and reservoirs regardless of the magnitude of their depletions.

Colorado

The Yampa River Basin in Colorado has nine reservoirs larger than 2,000 acre-feet (AF) active storage. These reservoirs range in size from 2,250 AF to 30,000 AF, with a total active storage capacity of 97,160 AF (Table 6). However, several include conservation pools and/or other accounts that generally are not fully exercised (i.e., drained and refilled) each year (Boyle Engineering 1999). Eight of these reservoirs are in the Upper Yampa Basin and one (Elkhead Reservoir) is in the Lower Yampa Basin.

Table 6. Principal reservoirs in the Yampa River Basin, active storage capacities and uses

Reservoirs	Capacity (AF)	Year Built	Principal Intended Use(s)
Stillwater Reservoir	5,175	1935	Supplemental irrigation supply
Yamcolo Reservoir	8,028	1981	Supplemental irrigation supply, M&I
Allen Basin Reservoir	2,250	1953	Supplemental irrigation supply
Stagecoach Reservoir	30,000	1988	Includes 11,000 AF for Tri-State, 15,000 AF for recreation, and 4,000 AF for M&I
Lake Catamount	7,422	1977	Used primarily for recreation
Fish Creek Reservoir	1,842	1942	M&I; annual releases have averaged 1,000 AF
Steamboat Lake	26,364	1961	5,000 AF for Hayden Station; 21,364 AF for instream flow and recreation
Pearl Lake	5,657	1959	Used exclusively for fisheries and recreation
Elkhead Reservoir	10,422	1974	Includes 1,668 AF M&I and 8,754 AF industrial
TOTAL	97,160		

The Colorado River Decision Support System (CRDSS) was used to estimate depletions from the Yampa River in Colorado during a 90-year period of record (October 1908-September 1998). On this basis, historic annual depletions averaged about 103,845 acre-feet (AF) in Colorado. Based on more recent water demands viewed in the same hydrologic context, current average depletions were estimated to be about 125,271 AF per year (Table 7). Agriculture (irrigation), thermoelectric generation (power), evaporation, and municipal and industrial (M&I) water users are the largest consumers. M&I water use includes mining, potable water supply, commercial and industrial uses (other than thermoelectric generation), livestock and snowmaking.

Table 7. CRDSS Historic/Current depletions from the Yampa River in Colorado by sector

Sector	Average annual depletions (AF)			Hydrologic Basis of Current Depletions
	Historic	Current	Change	
Agriculture (irrigation)	81,116	87,765	6,649	1975-1998 average[1]
Municipal & Industrial (M&I)	4,012	5,201	1,189	1998 consumption
Thermoelectric Generation	8,680	16,947	8,267	1985-1998 average
Exports (trans-basin diversions)	2,388	2,815	427	1975-1998 average
Reservoir Evaporation	7,649	12,543	4,894	Includes stock ponds
TOTAL	103,845	125,271	21,426	

[1] Taken directly from calculated data set. Depletions prior to 1975 estimated using 1975-1998 average calculated demands for the same month and hydrologic condition, without constraint of net cumulative decree. Does not include any fallow lands that may be irrigated in the future.

Based on projections of growth in human demand through 2045, the CRDSS estimates average annual future depletions from the Yampa River and its tributaries of about 155,375 AF per year in Colorado (Table 8), an increase of about 30,104 AF over current Colorado depletions. This estimate assumes there is sufficient water supply available to meet foreseeable demands.

Table 8. CRDSS Current/Future depletions from the Yampa Basin in Colorado by sector

Sector	Current[1] AF of depletions	Future (2045) average annual AF of depletions			Unlimited minus Current
		Limited[2]	Unlimited	Shortage[3]	
Agriculture	87,765	87,755	92,258	4,503	4,493
M&I	5,201	15,100	15,307	207	10,106
Power	16,947	32,350	32,350	0	15,403
Exports	2,815	2,814	2,917	103	102
Evaporation	12,543	12,543	12,543	0	0
TOTALS	125,271	150,562	155,375	4,813	30,104

[1] Based on estimated demands by use as of 1998 and limited by supplies and legal constraints.
[2] Limited by 1998 supplies and legal constraints; agriculture affected by senior M&I and power.
[3] Shortages = Unlimited minus Limited depletions.

The CRDSS also provides a geographic and temporal distribution of estimated current and future depletions from the Yampa River Basin (Table 9). This distribution does not include 4,813 AF of estimated shortages in Colorado. However, these shortages likely occur in Water District 58 (Upper Yampa Basin) and WD 44 (Lower Yampa Basin), which account for roughly two-thirds of all agricultural consumption in the Yampa Basin in Colorado (Figure 10, Table 10).

Table 9. Geographic and temporal distribution of CRDSS Current/Future depletions by Colorado Water District [1]

	Water District[1]	Average depletions (AF) during CRDSS 90-year period of record												
		OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
Current Demand	58	1,104	207	273	162	127	319	787	4,210	9,362	10,912	9,146	4,774	41,386
	57	558	399	459	441	378	461	341	1,155	2,584	3,088	2,950	1,647	14,460
	44	2,133	919	1,034	957	870	1,085	2,045	5,368	10,096	11,668	9,448	5,163	50,784
	54	314	0	0	0	0	0	442	1,890	3,908	4,302	3,405	1,501	15,763
	55	103	1	1	1	1	23	127	328	612	717	625	342	2,878
	TOTAL	4,212	1,526	1,767	1,561	1,376	1,888	3,742	12,951	26,562	30,687	25,574	13,427	125,271
2045 Demand [2]	58	1,565	600	621	596	525	780	1,180	4,595	9,775	11,515	9,642	5,166	46,562
	57	1,310	1,061	1,114	1,038	994	1,148	976	1,881	3,531	4,111	3,898	2,536	23,596
	44	3,086	1,451	1,732	1,812	1,627	1,930	2,881	6,365	11,270	12,881	10,650	6,052	61,733
	54	314	0	0	0	0	0	442	1,890	3,908	4,302	3,405	1,501	15,763
	55	108	4	5	5	4	27	130	329	613	718	626	343	2,908
	TOTAL	6,383	3,116	3,472	3,451	3,150	3,885	5,609	15,060	29,097	33,527	28,221	15,598	150,562
Difference	58	461	393	348	434	398	461	393	385	413	603	496	392	5,176
	57	752	662	655	597	616	687	635	726	947	1,023	948	889	9,136
	44	953	532	698	855	757	845	836	997	1,174	1,213	1,202	889	10,949
	54	0	0	0	0	0	0	0	0	0	0	0	0	0
	55	5	3	4	4	3	4	3	1	1	1	1	1	30
	TOTAL	2,171	1,590	1,705	1,890	1,774	1,997	1,867	2,109	2,535	2,840	2,647	2,171	25,291

[1] See Figure 10 (next page).

[2] Limited 2045 depletions, excluding CRDSS-estimated shortages of 4,813 AF.

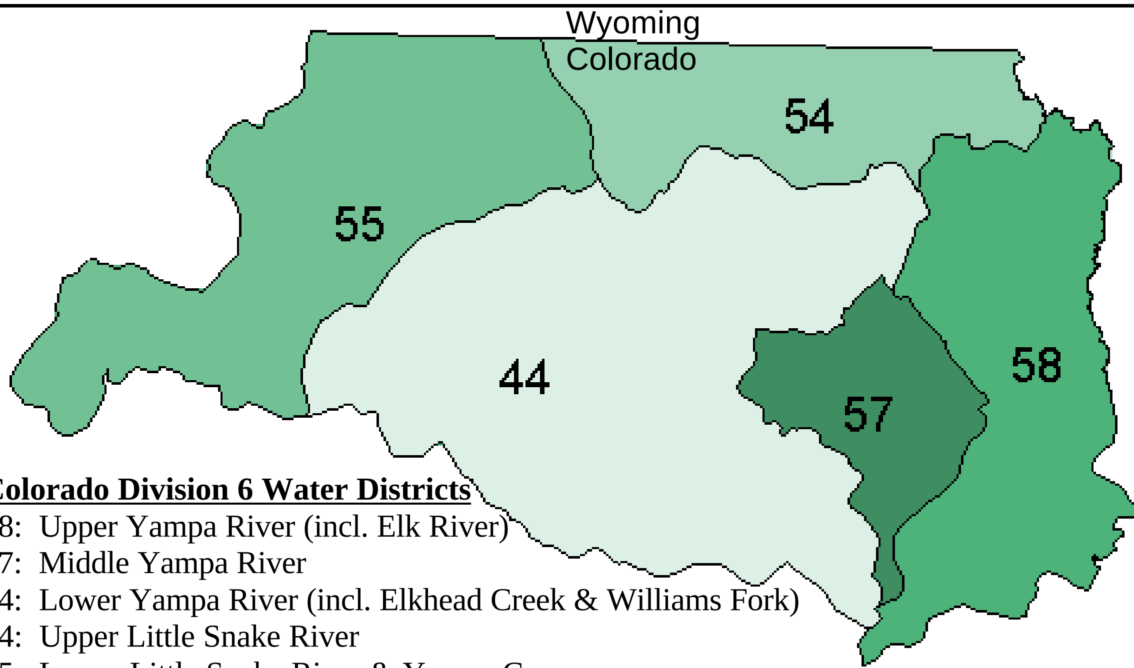

Figure 10. Yampa River Basin Water Districts in Colorado

Table 10. Distribution of CRDSS estimated depletions by sector and Water District

		Colorado Water District (Division 6)					
	Sector	58	57	44	54	55	TOTALS
Current Demand	Agriculture (irrigation)	30,012	9,089	30,750	15,763	2,151	87,765
	Municipal & Industrial (M&I)	2,735	484	1,969	–	13	5,201
	Thermoelectric Generation	–	4,887	12,060	–	–	16,947
	Exports (trans-basin diversions)	2,815	–	–	–	–	2,815
	Reservoir Evaporation	5,824	–	6,005	–	714	12,543
	TOTALS	41,386	14,460	50,784	15,763	2,878	125,271
2045 Demand	Agriculture (irrigation)	30,008	9,089	30,744	15,763	2,151	87,755
	Municipal & Industrial (M&I)	7,916	2,765	4,376	–	43	15,100
	Thermoelectric Generation	–	11,742	20,608	–	–	32,350
	Exports (trans-basin diversions)	2,814	–	–	–	–	2,814
	Reservoir Evaporation	5,824	–	6,005	–	714	12,543
	TOTALS	46,562	23,596	61,733	15,763	2,908	150,562

Figure 11 below shows how the pattern of CRDSS average depletions throughout the year differs between sectors. Depletions by agriculture for irrigation occur only during the growing season (April-October), while thermo-electric power generation consumes water more evenly during the year. Average peak consumption by agriculture occurs during July and is an order of magnitude higher than the current peak of any other sector (solid lines). The CRDSS predicts depletions by agriculture, trans-basin diversions (export) and reservoir evaporation will remain relatively stable through 2045, while M&I and power will experience significant increases (dashed lines).

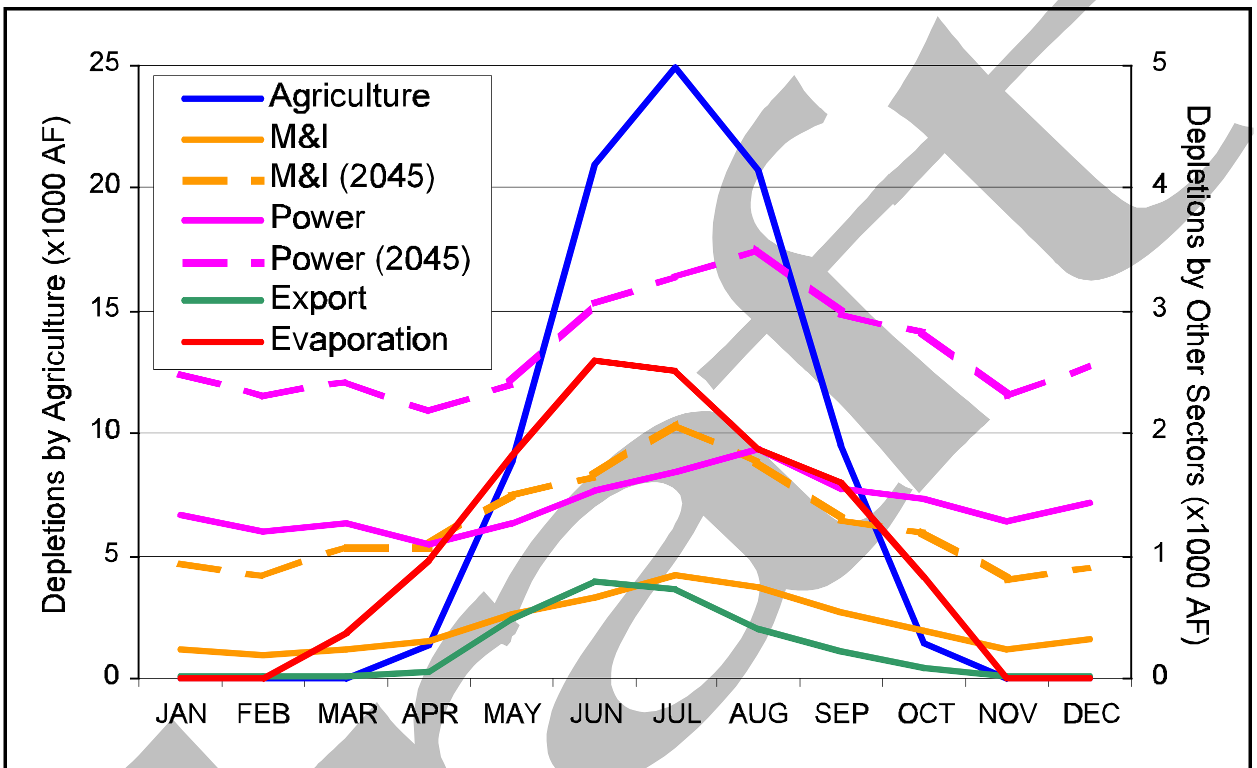

Figure 11. Temporal distribution of CRDSS depletions from the Yampa River Basin by sector

The CRDSS predicts that average annual depletions in excess of 150,562 AF in Colorado cannot be met every year with existing reservoir capacity. Therefore, new reservoirs may be developed in the future to satisfy the 4,813 AF of shortages in Colorado as expressed in Table 8. Moreover, Yampa Basin water users in Colorado wish to reserve an option to develop new water supplies, if necessary, to serve an additional 20,000-AF increment of demand (i.e., total of 50,000 AF above current depletions). For modeling purposes, this increment was assumed to be allocated equally between Agriculture, M&I and Power (i.e., 6,667 AF to each sector), with the entire demand placed on the mainstem of the Yampa River and distributed throughout the year according to each sector's current patterns of consumption. On this basis, the CRDSS predicted shortages of about 600 AF. This is reasonable for M&I and Power, which can be served from the mainstem. However, if a portion of irrigation demand were placed on smaller tributaries, shortages likely would be greater, because these streams may not yield enough water in late-summer to serve peak demands. To satisfy these shortages, new reservoir storage or greater utilization of existing storage may be required, with impacts to peak flows proportional to annual storage volumes.

Current information regarding the specific location(s) and volume(s) of any new reservoir(s) is insufficient to accurately predict these impacts. These impacts will be addressed if and when future depletions from the Yampa Basin approach the first 30,000-AF increment (see the section entitled **Depletion Accounting**). Formal Section 7 consultations We would be reinitiated with the FWS at that time to address the impacts of developing an additional 20,000-AF increment.

Yampa River flows were modeled in CRDSS under historic, current and future (limited) demands to assess the impacts to base flows due to current and future depletions in Colorado in historical context. These data provided the basis to estimate volumes of augmentation needed to meet instream flow targets for the endangered fishes within the critical habitat reaches of the Yampa River (see section entitled **Provide and Protect Instream Flows**). Differences between historic and current depletions (Table 7) are nested within the differences between historic and future (limited) depletions (Table 11).

Table 11. CRDSS Historic/Future depletions from the Yampa Basin in Colorado by sector

	Average annual CRDSS depletions (AF)		
Sector	Historic	2045 (Limited)	Difference
Agriculture (irrigation)	81,116	87,755	6,639
Municipal & Industrial (M&I)	4,012	15,100	11,088
Thermoelectric Generation	8,680	32,350	23,670
Exports (trans-basin diversions)	2,388	2,814	426
Reservoir evaporation	7,649	12,543	4,894
TOTALS	103,845	150,562	46,717

Because water would have to be released from storage to serve average annual depletions above 150,562 AF, depletions in excess of this amount should have minor, if any, impact to base flows. Moreover, return flows to the river from water stored on the peak of the hydrograph and released during base flow periods potentially could increase base flows and reduce both the frequency and magnitude of base flow augmentation needed in the future. Therefore, the estimated volume needed to augment base flows to compensate for an initial 30,000-AF increment of depletions is believed to be sufficient to satisfy a second 20,000-AF increment, as well.

Wyoming

The average annual water yield from the Little Snake River Basin is about 428,000 AF near its confluence with the Yampa River, roughly 28% of the combined flow of these two rivers. Streamflow data indicate that an average annual discharge of 372,600 AF passes the gage near Dixon, Wyoming. Below the Dixon gage, two significant tributaries, Muddy Creek and Willow Creek, contribute about 10,690 AF and 7,440 AF, respectively, for a total of 390,730 AF. These gaged flows already reflect losses due to depletions from the Little Snake River Basin upstream in both Colorado and Wyoming.

Sources of depletions in Wyoming include irrigated agriculture, environmental use, municipal in-basin use and trans-basin diversions for the City of Cheyenne. As in Colorado, irrigation is the largest water consumer in the Little Snake River Basin of Wyoming. Irrigation consumption in Wyoming was estimated by multiplying the number of acres devoted to each type of crop by a crop-specific Consumptive Irrigation Requirement (CIR). The CIR is the amount of irrigation needed in excess of rainfall to produce a crop. However, the maximum consumptive use of any crop is achieved only with an adequate water supply (States West Water Resources 2000).

The CIR at Dixon has been estimated to be about 1.9 feet for alfalfa and 1.75 feet for pasture grass or grass hay. For the Green River Basin Water Plan, these numbers were modified to include mountain meadow hay, for which irrigated lands above Baggs have been estimated to experience 1.63 feet of annual CIR (States West Water Resources 2000). There are 11,571 acres under irrigation above Baggs, 10,298 acres in meadow hay and 1,272 acres in alfalfa; below Baggs there are 4,358 irrigated acres, 3,879 acres in pasture grass/grass hay and 479 acres in alfalfa (Table 12).

Table 12. Calculation of Consumptive Irrigation Requirement, Little Snake River Basin

	Crop:	Grass/Meadow	Alfalfa	Totals
Above Baggs	Irrigated acreage	10,298	1,273	11,571
	CIR (feet)	1.63	1.90	–
	CIR (AF)	16,786	2,419	19,205
Below Baggs	Irrigated acreage	3,879	479	4,358
	CIR (feet)	1.75	1.90	–
	CIR (AF)	6,788	910	7,698
	Total acreage	14,194	1,755	15,929
	Total CIR (AF)	23,574	3,329	26,903

A review of irrigation diversion records show actual depletions less than CIR would predict, which is to be expected. Estimates of agricultural depletions, based on studies for the Little Snake Supplemental Irrigation Water Supply (High Savery) Project (Burns and McDonnell 1999), indicate the basin currently receives about 75% of its needs, with average annual irrigation depletions estimated to be 20,050 AF. Nevertheless, full CIR provides a reasonable estimate of the needs and aggregate consumptive demands for irrigation in the basin.

Annual depletions due to the High Savery Project are expected to average 7,724 AF. Of this amount, approximately 869 AF is attributed to evaporation from the reservoir, and 6,855 AF is attributed to irrigation. This project assumes that no additional acreage will be brought under irrigation; it will provide supplemental late-season water to currently irrigated lands. If 6,855 AF of irrigation depletions due to High Savery are added to 20,050 AF of estimated current irrigation depletions, total depletions for irrigation would be 26,905 AF, essentially 100% of the CIR. High Savery depletions have been formally addressed in a biological opinion issued by the FWS on July 14, 1999; therefore, this project is included under current depletions even though it has yet to be constructed.

The towns of Baggs and Dixon, with a combined population of only 375, account for 76 AF of in-basin M&I annual depletions. However, trans-basin diversions to serve the City of Cheyenne account for 14,400 AF of depletions, second only to irrigation in depletions from the Little Snake River. Total average annual depletions from the Little Snake River subbasin in Wyoming have been estimated to be 42,583 AF as of 1994 (Table 13). States West Water Resources (2000) estimated that depletions from the Little Snake in Wyoming could grow by 23,428 AF to an average annual depletion of 66,011 AF by 2045 (Table 14).

Table 13. Current estimated depletions from the Yampa Basin in Wyoming by sector

Sector	Average annual depletions (AF)	Hydrologic Basis
Agriculture (irrigation)[1]	26,905	Includes High Savery Project
Municipal and Industrial (M&I)	76	Consumption by towns of Baggs & Dixon
Exports (trans-basin diversions)	14,400	Cheyenne I & II (1995-1997 usage)
Evaporation[1]	1,202	Diked wetlands & small reservoirs
TOTAL	42,583	

[1] Portions of High Savery Project allocated to agriculture (6,855 AF) and evaporation (869 AF)

Table 14. Current/Future estimated depletions from the Yampa Basin in Wyoming by sector

Type of Use	Average annual AF of depletions		
	Current	Future (2045)	Difference
Agriculture (irrigation)	26,905	37,451	10,546
Municipal and Industrial (M&I)	76	88	12
Industrial	0	3,000	3,000
Exports (trans-basin diversions)	14,400	22,656	8,256
Evaporation	1,202	2,816	1,614
TOTALS	42,583	66,011	23,428

Using moderate growth estimates of 16% for both Baggs and Dixon, in-basin M&I depletions are expected to increase to 88 AF. Maximum annual capacity of the Cheyenne Stage I/II system (22,656 AF) is dictated by a one-fill limitation on Hog Park Reservoir. Although the City of Cheyenne has no immediate plans to enlarge this system, under current growth estimates, it should reach full capacity in the 2040-2050 timeframe (States West Water Resources 2000).

The difference between current and future agricultural depletions (10,546 AF) is attributable to eight small projects whose individual annual depletions range from 100 to 2,656 AF (Table 15).

Table 15. New depletions from the Little Snake River in Wyoming due to agriculture

Project Name	Surface	CIR[1]	Depletions (AF)
Miscellaneous stock reservoirs (~200)	variable	–	2,000
Dolan Mesa Canal (Savery Creek)	1,600	1.66	2,656
Willow Creek	1,000	1.66	1,660
Cottonwood Creek	500	1.66	830
Grieve Reservoir	300	1.66	500
Muddy Creek	1,200	1.77	2,100
Focus Ranch	200	0.50	100
Pothook – Beaver Ditch	400	1.77	700
TOTALS	5,200		10,546

[1] Crop-weighted basis: CIR above Baggs = 1.66; CIR below Baggs = 1.77.

Estimated future depletions due to evaporation (2,816 AF) represent a 1,614-AF increase over current depletions. These new depletions are attributed to a threefold expansion of constructed wetlands (1,000 AF) by the Little Snake River Conservation District, and the Little Snake River Basin Small Reservoirs Project (614 AF), 10 small impoundments with a combined surface area of 245 acres that the District proposes to build for stock watering, rangeland improvement, and wildlife enhancement. Two other impoundments will be constructed under existing funding, with a combined surface area of 19.5 acres and combined depletions of 49 AF, assuming a net evaporation of 30 inches. These two reservoirs were included under existing depletions (States West Water Resources 2000).

Combining depletions from the Little Snake River in Colorado and Wyoming results in basin-wide depletions as shown in Table 16. In this summary, Colorado Water District 54 depletions are included with Wyoming depletions above Baggs, while WD 55 depletions are included with Wyoming depletions below Baggs. Future depletions in Wyoming that were not attributed to a specific geographic region (i.e., 7,816 AF total depletions for evaporation, miscellaneous stock reservoirs, and industrial uses) were prorated in the same proportion as regional depletions by irrigation, assigning 5,471 AF (70 %) to the region above Baggs and 2,345 AF (30 %) to the region below Baggs.

Table 16. Basin-wide distribution of Current/Future depletions from the Little Snake River

Region and State		Average annual depletions (AF)		
		Current	Future	Change
Above Baggs	Colorado (WD 54)	15,763	15,763	0
	Wyoming	34,540	53,067	18,527
	SUBTOTALS	50,303	68,830	18,527
Below Baggs	Colorado (WD 55)	2,878	2,908	30
	Wyoming	8,043	12,944	4,901
	SUBTOTALS	10,921	15,852	4,931
BASIN-WIDE TOTALS		61,224	84,682	23,458

It bears mentioning at this point that although all of the irrigation depletions attributable to the High Savery Project have been assigned to Wyoming, this project also serves about 3,400 acres of irrigated lands in Colorado. This acreage is roughly 14% of the 24,000 acres served by the project. On a *pro rata* basis, therefore, we estimate that about 960 AF out of the 6,855 AF average annual irrigation depletions by the project can be attributed to lands in Colorado served under Wyoming water rights.

Depletion Accounting

Water depletions are defined as a reduction in the undepleted volume of water that, without such depletions, would have reached the critical habitat of the endangered fishes. Current average annual depletions from the Yampa River in Colorado were estimated to be about 125,000 AF, while comparable depletions from the Little Snake River in Wyoming were estimated to be about 43,000 AF. Based on projections of future water demands for human use, increments of about 30,000 AF per year in Colorado and 23,000 AF per year in Wyoming were added to these current depletions to account for water development *circa* 2045. Recovery actions which follow in subsequent sections of this plan are intended to offset the impacts of the aggregate depletions of about 155,000 AF in Colorado and 66,000 AF in Wyoming.

Periodically, actual water consumption from the Yampa River Basin in Colorado and Wyoming must be quantified to determine if and when it would be necessary to reinitiate consultations with the FWS under Section 7 of the ESA for any additional increment(s) of water development above those which were considered in this plan.

This section describes the accounting system that will be used to determine changes in the water depletions addressed in this plan. This accounting process will quantitatively measure increases in water depletions as they occur and identify when increments of about 30,000 AF in Colorado and 23,000 AF in Wyoming have been fully utilized. In Colorado, the USBR prepares a *Consumptive Uses and Losses Report* (CULR) every 4 years, using information provided by the CWCB.

Every 4 years, beginning in 2005, in the CULR, the States of Colorado and Wyoming will report to the Recovery Program the actual or estimated volume of depletions from the Yampa River and its tributaries in their respective jurisdictions. When the volume of depletions in either State reaches its total allowance of current depletions plus the increment of future depletions, this Plan and the Cooperative Agreement with the FWS to implement the Plan may be modified or revoked. At that time, the FWS is expected to reinitiate intra-Service consultations under ESA Section 7. However, if one of the States has not yet reached its full increment of future depletions, this Plan shall remain in effect for that State unless that State, at its discretion, elects to enter into a new Cooperative Agreement with the FWS and the other State to implement a modified Plan.

Framework for Recovery Actions and Cooperative Agreement

This plan provides a framework for recovery actions designed to offset impacts to the four listed endangered fish species of the Upper Colorado River Basin due to current depletions and foreseeable future depletions from the Yampa River and its tributaries. Current average annual depletions from the Yampa River Basin have been quantified as 125,271 AF in Colorado and 42,583 AF in Wyoming. By the year 2045, depletions are expected to increase by 30,104 AF in Colorado and 23,428 AF in Wyoming (Appendix B). This plan stipulates that a variety of recovery actions be taken to offset the impacts of these depletions and to promote recovery of the endangered fishes . In addition, this plan prescribes certain actions to be taken specifically to quantify and minimize or eliminate incidental take of these species due to water development (see section entitled <u>Reduce/eliminate entrainment of Colorado pikeminnow at diversion structures</u>).

To implement this plan the FWS will sign a Cooperative Agreement with the States of Colorado and Wyoming. This constitutes a "federal action" by the FWS, for which the FWS must consult under Section 7 of the ESA, as well as comply with the requirements of the NEPA. Due to the basin-wide scope of depletion impacts and recovery measures, we anticipate that a programmatic biological opinion (PBO) will be developed for the Yampa River Basin as a product of an intra-Service Section 7 consultation. The consultation and resultant Yampa PBO would determine if this plan would jeopardize the continued existence of the listed fishes or adversely modify their designated critical habitats. It is intended that the Yampa PBO would continue to be in effect unless specific identified conditions (i.e., reinitiation criteria) occur or until all four of the endangered fishes of the Upper Colorado River Basin are removed from the list of threatened and endangered species.

Nevertheless, the impacts of new projects on threatened and endangered species would need to be identified and addressed in future Section 7 consultations. These consultations would determine, among other things, if construction and operation of these projects would cause levels of incidental take higher than those anticipated in the Yampa PBO. For example, new diversion structures in occupied habitat that impede fish passage or entrain endangered fish may cause impacts not considered in the PBO, in which case project proponents may be required to provide for passage or incorporate certain features, such as screens, into their structures to minimize entrainment. The incremental cost of such feature(s) would be borne by the project proponent(s). Although existing structures in critical habitat on the Yampa River were found not to impede passage by Colorado pikeminnow (Modde et al. 1999), their potential to entrain Colorado pikeminnow is not yet known.

The RIPRAP provides for the Recovery Program to identify and rectify problems of fish entrainment at structures as they existed at the inception of the Recovery Program in 1988. However, if existing structures subsequently are proposed to be modified in such a way that they would likely impede passage of or entrain endangered fishes, then additional modifications may be required of those projects to reduce or eliminate take.

The recovery actions described herein are intended to contribute to the ultimate recovery of these species, consistent with the purpose of the Recovery Program. These RIPRAP actions are classified into five broad categories:

1. Reduce Negative Impacts of Nonnative Fishes
2. Provide and Protect Instream Flows
3. Restore Habitat (Habitat Development and Maintenance)
4. Manage Genetic Diversity/Augment or Restore Populations
5. Monitor Populations and Habitat

These recovery actions, and the process for their development, are specified below, along with approaches to account for depletions, monitor fish populations, and evaluate the effectiveness of these actions. Schedules to initiate and/or complete recovery actions will be specified upon their incorporation or clarification in annual revisions to the RIPRAP. The Recovery Program will be responsible for funding and implementing these recovery actions.

<u>Reduce Negative Impacts of Nonnative Fishes</u>

Background

Controlling nonnative fishes is necessary for recovery of Colorado pikeminnow, humpback chub, bonytail and razorback sucker in the Upper Colorado River Basin. Nonnative fishes of greatest and most immediate concern in the Yampa River are northern pike (*Esox lucius*), smallmouth bass (*Micropterus dolomieui*) and channel catfish (*Ictalurus punctatus*).

The states of Colorado, Utah and Wyoming adopted *Procedures for Stocking Nonnative Fish Species in the Upper Colorado River Basin* (U.S. Fish & Wildlife Service 1996) to help prevent competitive and predatory nonnative species from escaping into the Upper Colorado River system. Before nonnative fishes can be stocked into ponds and reservoirs that connect with the river, these nonnative stocking procedures (NNSP) call for outlets of these waters to be screened to prevent stocked fish from escaping to the river. The NNSP apply to both existing and new ponds and reservoirs. The Recovery Program may retrofit existing facilities to prevent or reduce escapement by nonnatives. However, depending upon their location and connectivity with the river, new water storage projects in the Yampa River Basin intended to support warmwater or coolwater sportfish, may need to consider nonnative fish control measures (e.g., screening to prevent escapement and/or stocking restrictions) in the project design and cost.

Originally introduced as a game fish in Elkhead Reservoir in 1977, northern pike accidentally became established in the Yampa River in the early 1980s when the species escaped from the reservoir and invaded the Yampa River via Elkhead Creek, about 4 miles upstream from Craig, Colorado (Tyus and Beard 1990). Since then, northern pike have established a reproducing population in the Yampa River and have expanded their numbers and range in both the Yampa and Green rivers. Northern pike now occur throughout the Yampa River within critical habitat of the endangered fishes, as well as upstream from Craig, where seasonally flooded, vegetated backwaters and sloughs provide suitable habitat for spawning (Nesler 1995). Many large adult northern pike move downstream from their spawning reaches into occupied critical habitat (Nesler 1995), where they pose a competitive or predatory threat to endangered fishes (Wick et al. 1985; Tyus and Karp 1989; Tyus and Beard 1990; Nesler 1995), as well as to roundtail chub (*Gila robusta*), flannelmouth sucker (*Catostomus latipinnis*) and other native fishes (Tyus and Beard 1990; Martinez 1995; Nesler 1995). The northern pike is an opportunistic top predator. Young-of-year northern pike feed on zooplankton and aquatic insects and shift to a diet of fish and other vertebrates as they mature. Northern pike appear to select prey based on the size and abundance of the prey organisms more than the species of prey (Scott and Crossman 1973; Becker 1983; Raat 1988). Radio-telemetry and mark-recapture records indicate that the species uses flooded backwaters and sloughs in the Yampa River during spring runoff and that most individuals (78%) tend to remain within one-mile sections of river (Nesler 1995). Sexually mature northern pike are especially vulnerable to capture as they move from the main channel into off-channel spawning areas (Mann 1980; Nesler 1995).

Smallmouth bass are non-migratory, sight-feeding carnivores that prey on fish, crayfish, and aquatic insects (Scott and Crossman 1973; Carlander 1977; Becker 1983). This fish invaded the Yampa River in significant numbers when Elkhead Reservoir was drawn down in 1992; they are now routinely collected in both the Yampa and Upper Green rivers (McAda et al. 1994). Prior to 1992, the species was captured only incidentally in riverine habitats. Suspected impacts include predation on young of native fishes (Hawkins and Nesler 1991) and competition with adults.

Channel catfish were first introduced into the Upper Colorado River Basin in 1892 (Tyus and Nikirk 1988) and are now considered common or abundant throughout much of the Upper Basin (Tyus et al. 1982; Nelson et al. 1995). This species is one of the most prolific predators in the Upper Colorado River Basin and is thought to have the greatest adverse effect of all the nonnative fishes on the endangered fishes (Hawkins and Nesler 1991; Lentsch et al. 1996; Tyus and Saunders 1996). Channel catfish are found in low- to moderate-gradient rivers with sand, gravel, or boulder substrates. Most adult channel catfish are found in large, deep pools and runs during daylight, but move to riffles or shallow pools at night to feed. Young channel catfish congregate in riffles or shallow pools. Channel catfish spawn in late spring through early summer when water temperatures reach about 20–24°C. Adults seek dark secluded areas associated with cavities or cover to build their nests and spawn (Sigler and Miller 1963; McClane 1965; Pflieger 1975; Simpson and Wallace 1978). It has been demonstrated that spawning adults often migrate long distances in search of suitable spawning sites (Smith 1988; Gerhardt 1989; Smith and Hubert 1989; Gerhardt and Hubert 1990). However, recent radio-telemetry studies of channel catfish in the Yampa River have shown that these fish often remain in the same river reaches throughout the year (Irving and Karp 1995; Modde et al. 1999). Apparently, suitable spawning habitat is available locally in Yampa Canyon. Removal of channel catfish from the Yampa River is a high priority of the Recovery Program, especially in reaches between Craig and Deerlodge Park and in Yampa Canyon within DNM.

Hawkins and Nesler (1991) included channel catfish and northern pike in their ranking of nonnatives of greatest concern in the Colorado River Basin because of their documented or suspected negative interactions with native fishes, including predation or attempted predation on native fishes, and identified smallmouth bass as a species of increasing concern because of its increasing abundance, habitat preferences, and fish-eating habits. These nonnatives were specifically targeted for control in this plan because of their potential negative predatory or competitive effects on resident subadult and adult Colorado pikeminnow in the middle Yampa and lower Yampa upstream from Yampa Canyon, and similar effects by nonnatives (primarily channel catfish) on humpback chubs in Yampa Canyon within DNM.

Aquatic Wildlife Management Plan

The following control strategies/options were developed for each of the three target species using Lentsch et al. (1996), Tyus and Saunders (1996), and the Colorado Division of Wildlife (CDOW 1998) as guidance, with consideration given to maintaining local recreational fisheries for these valued sportfish, where possible. Lentsch et al. (1996) reviewed the distribution and biology of nonnative fishes in the Upper Basin; these authors and Tyus and Saunders (1996) also presented options for their control. In its *Aquatic Wildlife Management Plan for the Yampa River Basin*, the CDOW (1998) recommended the following strategies/options to manage nonnative fishes to reduce their impacts on endangered and other native fishes:

<u>Upper Yampa River</u>

- Assess predation impact of northern pike upstream from the Elk River confluence and upstream from Stagecoach Reservoir; eradicate northern pike as feasible. Encourage angler harvest as the primary method of northern pike control in Stagecoach Reservoir.

<u>Middle Yampa River</u>

- Manage primarily for conservation of native fish populations. Secondarily, manage for brown trout (*Salmo trutta*), rainbow trout (*Oncorhynchus mykiss*), Snake River cutthroat (*O. clarki* subspecies), and mountain whitefish (*Prosopium williamsoni*) fisheries, such that predation by large nonnative salmonids does not impact recruitment of native fishes.

- Develop black bass (i.e., smallmouth bass and largemouth bass [*Micropterus salmoides*]) and northern pike fishing in off-channel ponds and reservoirs in accordance with provisions of the NNSP. Encourage local use of "Fishing is Fun" federal grant projects.

- Develop access/lease agreements with private landowners whose off-channel ponds or reservoirs are suitable under provisions of the NNSP to expand fishing opportunities for either coldwater or warmwater fish species.

- Reduce the abundance of northern pike, smallmouth bass, and white sucker (Catostomus commersoni) in riverine habitats by capturing and translocating these fish to local waters suitable under provisions of the NNSP.

<u>Elkhead Reservoir</u>

- Manage for black bass, black crappie (*Pomoxis nigromaculatus*), and seasonal trout fishing in accordance with provisions of the NNSP.

- Stock the reservoir (in accordance with the NNSP) with smallmouth bass, northern pike, and channel catfish removed from the middle and lower reaches of the Yampa River.

Lower Little Snake River

- Emphasize management of the lower mainstem Little Snake River for populations of endangered and other native fishes.

Lower Yampa River

- Manage downstream from the Williams Fork confluence primarily for endangered and other native aquatic wildlife. Control the abundance of non-salmonid nonnative fishes as necessary to protect native fish populations and enhance recovery of endangered fishes.

- Remove northern pike, smallmouth bass, and channel catfish and translocate these fish to local waters suitable under provisions of the NNSP.

- Develop access/lease agreements with private landowners whose off-channel ponds or reservoirs are suitable under provisions of the NNSP to expand fishing opportunities for either coldwater or warmwater fish species.

Green River within Colorado

- Manage primarily for endangered and other native aquatic wildlife. Control the abundance of non-salmonid nonnative fishes as necessary to protect native fish populations and enhance recovery of endangered fishes.

Control Actions for Nonnative Fishes in the Yampa River

Recovery actions identified in the April 2000 revision of the RIPRAP (Green River Action Plan: Yampa and Little Snake Rivers) include activities to reduce the impacts of sportfish and other nonnative fishes on the endangered fishes. Because collection techniques and equipment are not discriminating, other nonnative species, such as white sucker (*Catostomus commersoni*) and black crappie (*Pomoxis nigromaculatus*), though not specifically targeted for control, may be taken fortuitously with the target species. These species would be removed, but not be translocated, except to serve as forage for the translocated species.

Ongoing control actions

- Implementation of the Nonnative Stocking Procedures (NNSP)

  The CDOW has followed the interstate agreement to implement the NNSP with respect to stocking nonnative fishes in Yampa Basin reservoirs and ponds, and has stocked no warmwater fish in the Yampa Basin since 1994. Recently, in accordance with provisions of the NNSP, CDPOR withdrew its application to stock yellow perch (*Perca flavescens*) in Stagecoach Reservoir.

- Non-lethal removal and translocation of northern pike

  A key component of this effort is identification and acquisition of a sufficient number of suitable local translocation sites. To date, the only sites that have been identified are three ponds (totaling about 15 surface acres) located at the Yampa State Wildlife Area (SWA) adjacent to the Yampa River near Hayden, Colorado. However, because these ponds reconnect to the river during spring runoff, they are unavailable until after the run-off period and are considered an interim solution that requires additional measures, such as removal of northern pike prior to the following run-off period, to ensure that they do not return to the river. Other potential translocation sites that require further evaluation include private ponds or reservoirs (with public access) isolated from the Yampa River and its tributaries, Elkhead Reservoir, and Rio Blanco Lake, an off-channel reservoir on the White River downstream from Meeker, Colorado. The first alternative probably would require developing access/lease agreements with private landowners and possibly involve implementing an incentive program with available funding to encourage voluntary participation by landowners. Elkhead Reservoir and Rio Blanco Lake have existing sport fisheries, including northern pike (Elkhead Reservoir also contains smallmouth bass and Rio Blanco Lake also contains channel catfish), and are large enough to accommodate future translocation needs. Although translocation to sites within the Yampa Basin are preferred, this option does not preclude translocation outside the Basin (e.g., Rio Blanco Lake) or lethal removal, if suitable in-basin translocation sites are inadequate to receive all northern pike removed from the river.

Recovery Program project number 98 was initiated in 1999 under the lead of the CDOW to remove adult northern pike from the Yampa River via electrofishing and netting techniques. Northern pike are captured and removed from spring backwater and shoreline habitats along the Yampa River for approximately 100 miles in the critical habitat reach above Yampa Canyon (Craig to Deerlodge Park). Other nonnative species, such as white sucker and black crappie, were taken fortuitously with northern pike; these fish were removed, but not translocated, except as forage for the northern pike.

In 1999, 80 northern pike were removed from the Yampa River and placed in the SWA ponds (John Hawkins, Larval Fish Laboratory, personal communication), in accordance with the NNSP, which preclude stocking nonnative fishes into facilities from which their escapement back to the river is probable. The purpose of this project is to reduce the abundance of northern pike in the Yampa River while providing a sport fishery accessible to Yampa Valley anglers. In 2000, about 350 northern pike were translocated to Rio Blanco Lake (John Hawkins, Colorado State University, Larval Fish Laboratory, personal communication), because in-basin sites meeting the criteria of the NNSP agreement were unavailable. All other nonnative fishes were returned to the river. This project is scheduled to continue through 2002 and, if successful, could be extended beyond 2002.

Further development, implementation, and refinement of this translocation project will determine the level of northern pike removal necessary to minimize the threat of negative interactions with endangered and other native fishes. Measures of success of this project may include (1) decreasing abundance and capture indices for northern pike at habitat sites and over a specified period of time, (2) changes in length-frequency distribution of northern pike due to fewer large adult fish, (3) increased abundance and capture indices of native fish species in habitats sampled, (4) increased abundance of juvenile life stages of native fish species, and (5) increased recruitment of Colorado pikeminnow into the Yampa population at sizes of 350–450 mm total length.

- Lethal removal of channel catfish from Yampa Canyon

  Recovery Program project number 88 started in 1998 and will continue through 2001. It involves mechanical, lethal removal of channel catfish from reaches of the Yampa River in DNM between Laddie Park (rivermile 10) and Deerlodge Park (rivermile 46) using a multiple-pass (Leslie/DeLury) depletion method with several gear types (e.g., baited and unbaited hoop nets, set lines, and angling). Catfish and other nonnative fish captured during this project are removed from the river and killed. Preliminary results of this pilot project suggest that the channel catfish population in Yampa Canyon can be depleted by harvesting, and catfish control in Yampa Canyon following this approach should continue (T. Modde, Principal Investigator, U.S. Fish and Wildlife Service, Vernal, Utah). Moreover, this methodology should be extended to the critical habitat reach of the Yampa River from Deerlodge Park upstream to Craig, Colorado. Harvest methods most effective for channel catfish in this reach need to be determined, but would include block-trapping backwater habitats similar to block and shock methods employed by Nesler (1995). Removal of channel catfish and other nonnative fish species from Yampa Canyon will resume in 2001. Further development, implementation, and refinement of this project will help determine the level of channel catfish removal necessary to minimize the threat of negative interactions with endangered and other native fishes.

- Removal of angler bag and possession limits in Colorado

  Applies to northern pike statewide, as well as channel catfish, largemouth bass, smallmouth bass, walleye (*Stizostedion vitreum*), green sunfish (*Lepomis cyanellus*), bluegill (*L. macrochirus*), black bullhead (*Ameiurus melas*) and black crappie in the Yampa River Basin and the Green River in Colorado.

- Advanced notification of releases from Elkhead Reservoir

  The City of Craig, Colorado, has agreed to notify the CDOW and Recovery Program in advance of any drawdown releases from Elkhead Reservoir. The CDOW will sample the tailwaters to evaluate escapement of nonnative fishes from Elkhead Reservoir during the drawdown. Game fish captured will be returned to Elkhead Reservoir or translocated to other suitable waters in accordance with provisions of the NNSP.

<u>Future control actions</u>

- Continue all of the above ongoing actions and evaluate their effectiveness in reducing the impacts of nonnative fish species and enhancing native fish species.

- Design and install fish screens as necessary to control escapement of nonnative fishes.

  Elkhead Reservoir would provide a significant, centrally located translocation site; but before it can be used as such, a fish barrier must be installed to screen reservoir outflows to reduce or eliminate escapement of nonnative fishes into the Yampa River. Reservoir drawdowns in 1992 and 1999, which resulted in northern pike escaping to the river via Elkhead Creek, served to highlight the need for a fish barrier at Elkhead Reservoir. As part of this plan, the Recovery Program would design and install a fish barrier at Elkhead

Reservoir. A net-type barrier (nominal ¼-inch mesh polyester) was installed at Highline Lake near Fruita, Colorado. The barrier was installed in the spillway approach of Highline Lake in 1999 and has been under evaluation to ascertain the feasibility of constructing and operating fish barriers at similar facilities in the Upper Basin. Preliminary findings suggest that this specific application has been effective. However, while Highline Lake is fed primarily by diverting water from the Colorado River, Elkhead Reservoir receives unregulated inflows from Elkhead Creek. Spring runoff produces peak spillway flows an order of magnitude greater than those at Highline. The Recovery Program has contracted with Owen Ayres Associates to design a fish barrier to screen both the spillway and gated outlet at Elkhead Reservoir. Feasibility and design work will be completed in 2001. However, screening Elkhead Reservoir must be coordinated with any planned reservoir enlargement or other modification(s) of the spillway or outlet structure. In the future, the Recovery Program also may screen other existing ponds and reservoirs from which escapement of nonnative fishes poses a significant threat to the endangered fishes.

- Reduce or eliminate access by northern pike to spawning/nursery habitats

Eliminating or reducing northern pike reproduction in the Yampa River potentially is the most effective long-term solution for their control. As previously mentioned, vegetated, low-velocity habitats connected to the main channel during spring runoff are the preferred spawning areas for northern pike. Denying sexually mature fish access to these habitats will negatively impact their reproduction. Existing irrigation systems often are designed in such a way that intake or outflow canals act as slack-water sloughs, which can serve as northern pike spawning habitats. Reconfiguring these canals to create a more flow-through (i.e., flowing-water) system or putting the outflow water in pipes that can be easily screened might be less costly and preferable to screening the entire canal. Also, existing irrigation systems often have supply or collection ponds associated with them. These ponds may provide spawning areas for northern pike; these impoundments could be managed through chemical treatment or water-level manipulation to remove northern pike or reduce or eliminate their successful reproduction.

Habitat manipulation conceivably could occur wherever sloughs and backwater habitats are formed by natural or artificial processes. However, identification and investigation of these sites, as well as the implementation of any potential remedies, would depend upon the willingness of the affected landowners to participate. The Recovery Program or the CDOW through Great Outdoors Colorado (GOCO) grants may provide financial incentives to those landowners on whose property natural or artificial processes create conditions conducive to northern pike propagation, potentially including many headgates and return flows throughout the Yampa River Basin. For new facilities, it would be most cost-effective to incorporate nonnative fish control measures in their design before they are constructed.

Options include (1) low-cost, low-maintenance screens on off-channel sloughs (natural or artificial), (2) screening or reconfiguring irrigation head gates (inflow canals) and outflow canals, (3) chemical treatment or water-level manipulation in irrigation supply/collection ponds to reduce abundance and reproduction of northern pike, and (4) increasing private landowner/water user participation in above habitat manipulation actions.

The CDOW has developed and submitted to the Recovery Program a scope of work to implement a pilot program in 2001 to identify and screen northern pike spawning habitat in the Yampa River from Steamboat Springs to Craig, Colorado. If the pilot study proves successful, this program may be expanded to include other sites. In addition, northern pike also may be captured and removed from a few selected spawning sites. Anticipated initial steps in developing a spawning habitat control program are to: (1) identify potential sites to assess as northern pike spawning habitat by contacting representatives of water conservation districts and water user associations in the Yampa River Basin; (2) visit all identified sites to evaluate their potential as northern pike spawning habitat, determine the feasibility and cost of any control measures and materials necessary to implement; (3) select 2-3 sites for a pilot study to test screening design and materials, and investigate operational constraints and effectiveness; and (4) develop recommendations and a 2002 scope of work to improve and/or expand future control measures.

- Expand the reach of northern pike and smallmouth bass removal and translocation.

  Based on results of spawning habitat control activities, northern pike and smallmouth bass may be removed from reaches of the Yampa River upstream from critical habitat; these fish would be translocated to NNSP-suitable receiving waters.

- Translocate northern pike to other ponds and reservoirs meeting NNSP criteria.

  Identify and acquire in-basin translocation sites with angler access. See also *Design and install fish screens as necessary to control escapement of nonnative fishes* above.

  The *Yampa River Basin Small Reservoir Study* (Montgomery Watson 2000) identified 24 potential sites for construction of small reservoirs in the Yampa Basin based on a number of factors, including their ability to satisfy an identified demand and provide potential recreational opportunities. The feasibility of constructing reservoirs on these sites will be further evaluated; such evaluations will include the potential of these reservoirs to support public fisheries. If reservoirs that are likely to provide public fisheries are selected for construction, their design should incorporate outlets that meet NNSP criteria, so that northern pike, smallmouth bass, or channel catfish removed from the Yampa River may be translocated there.

- Deplete nonnative fish populations through increased angler harvest.

  In conjunction with removal of bag and possession limits by the State of Colorado, local promotion of fishing derbies, and increased angler access to river fishing upstream from critical habitat can deplete populations of northern pike, channel catfish and smallmouth bass in the Yampa River. Options include: (1) financial incentives (e.g., state-sponsored bounties or locally sponsored sportfishing derbies) for anglers who remove target species from the river; anglers would be paid for each target fish removed from the river (due to the risk of incidental take of Colorado pikeminnow by increased angling within critical habitat, financial incentives should be offered only in areas outside critical habitat); and (2) increasing angler access to the river by negotiating easements with private landowners.

Option 1 requires approval of the CDOW Director. Under Colorado Revised Statutes 33-1-106, “any person desiring to conduct tagged or marked fishing contest in public waters shall make application to the Division of Wildlife on a form provided by the Division of Wildlife at least 60 days prior to the proposed contest date. Such application shall be accompanied by a non-refundable fee of twenty (20) dollars.” Also, “no tagged or marked fish contest shall be permitted on any stream, river, or other flowing water or any water designated as a Gold Medal or Wild Trout water.” The key in these restrictions is the use and capture of tagged fish as objectives of the contest. This does not preclude contests in the Yampa River as long as no fish are marked as specific qualifiers for prizes.

- Lethal removal of northern pike, channel catfish, and smallmouth bass

  Remove from the Yampa River and destroy nonnative target species if translocation is not feasible. Remove these species from public ponds and reservoirs that do not meet NNSP criteria. Provide incentives for their removal from private ponds and reservoirs that do not meet the NNSP criteria.

Provide and Protect Instream Flows

Background

Depletions, as a percentage of natural, undepleted flows, affect low flows to a greater extent than they do spring peak flows. However, peak flows play a significant role in the life history of the endangered fishes. Flows during non-runoff periods from July through March will be augmented to compensate for the impacts of depletions, but such augmentation must be tempered by the need to protect peak flows.

Typically, flows in the Yampa River are lowest during the months of August through October. Modde et al. (1999) recommended that daily average flows at the Maybell gage should not fall below 93 cfs during this period in the future with any greater frequency, magnitude or duration than they would have under historical demand conditions. Based on initial results of hydrologic modeling with the Colorado River Decision Support System (CRDSS), this low-flow period was expanded to encompass all base flows from July through October. The FWS adopted the flow recommendations of Modde et al. for this period and further recommended that Yampa River flows at Maybell not fall below 124 cfs during the winter (November–March) with any greater frequency, magnitude or duration than they would have under historical demand conditions. The FWS has made no numerical flow recommendations with respect to spring peak flows, except that impacts to peak flows should be minimized to the greatest extent practicable.

The CRDSS for the Yampa River is a hydrologic model that uses a 90-year historical set of atmospheric and hydrologic conditions as a template on which to compare alternative sets of future water supply and demand conditions. The period of record for the Yampa River CRDSS encompasses water-years 1909-1998 (October 1, 1908 - September 30, 1998). While no model can predict the future with absolute certainty, climatic and hydrologic patterns in the recent past reasonably reflect those likely to occur in the near future. In this context, the CRDSS applies a statistical probability of future atmospheric and hydrologic conditions that affect both the supply of and demand for water.

Stream discharge in AF/month was estimated at Maybell using the CRDSS under historic, current and 2045 demand conditions. These monthly outputs subsequently were distributed on a daily basis in proportion to gaged flows during the same time period as follows: Daily average gaged flows were expressed as a percentage of total gaged flows for each month in the 90-year period of record; to determine flows in AF/day each monthly CRDSS output was multiplied by its corresponding daily percentages; these flows were converted to average daily cfs by applying the following conversion factor: AF/day ÷ 1.98 = daily average cfs.

Using these synthesized daily flows, the FWS estimated gross deficits of summer (93 cfs) and winter (124 cfs) flow targets (Figure 12). White bars in Figure 12 represent daily net deficits of flow targets in historical context based on the difference between the CRDSS-predicted future average daily flows in cfs and the lesser of 93 cfs or the corresponding CRDSS-estimated historic daily average flows. Days when CRDSS-estimated future streamflows exceeded 93 cfs were not used to offset any deficits. Annual net deficits were calculated by subtracting historic gross deficits from future (or current) gross deficits (Table 17). Net deficits represent the smallest augmentation volumes needed to precisely satisfy the flow targets in their historical context and were used to quantify augmentation needs.

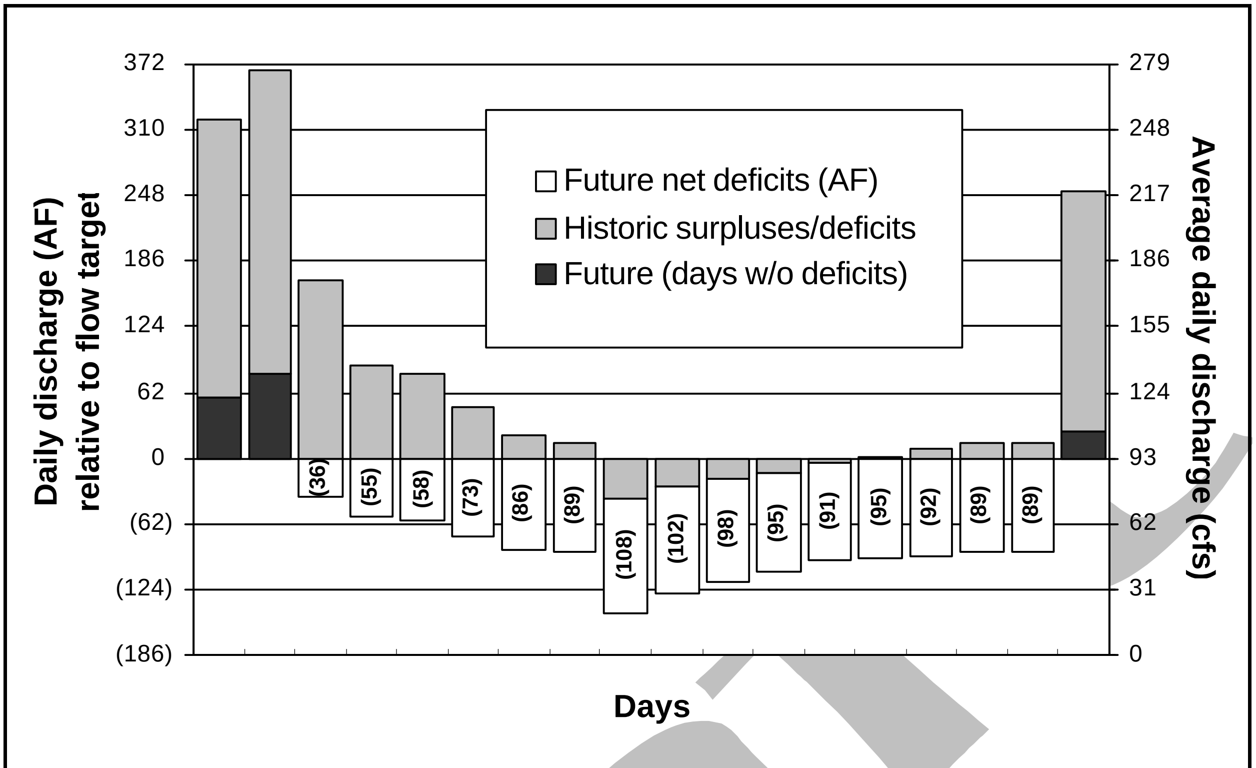

Figure 12. Illustration of hypothetical daily deficits of fish flow targets

Net deficits under 2045 demand conditions ranged from zero during all moderately wet to wet years ($\leq$30% exceedance), up to 9,689 AF in 1977, an extremely dry year (100% exceedance). For the driest 10% (9/90 years) annual net deficits average 8,390 AF, while in 80/90 years annual net deficits are less than 6,000 AF (Table 17). On this basis, the FWS concluded that 6,000 AF, plus an allowance for transit losses, would be sufficient to augment flows for the endangered fishes in all but the driest years through 2045. This volume also would serve to reduce, though not totally eliminate, deficits in the driest years (Table 18).

A Water Subcommittee composed of Yampa River Basin water users and representatives from the Colorado River Water Conservation District, Colorado Water Conservation Board, Colorado Water Resources Division, FWS, and The Nature Conservancy adopted this volume, to which was added 1,000 AF (16.67%) to account for transit losses from Steamboat Lake or Stagecoach Reservoir, to evaluate augmentation water supply alternatives. Due to the shorter distances involved, water delivered from Elkhead Reservoir or from a new tributary reservoir closer to critical habitat should experience smaller transit losses than water delivered from Steamboat or Stagecoach.

Table 17. Comparison of CRDSS average annual historic, current and future (2045) deficits of fish flow targets in the Yampa River at Maybell under various hydrologic conditions[1]

Hydrologic Conditions[1]	Average gross deficits			Average net deficits[2]	
	Historic	Current	2045	Current	2045
Wet (0-10% exceedance)	0	0	0	0	0
Moderately wet (11-30% exceedance)	0	0	0	0	0
Average (31-70% exceedance)	92	183	709	91	617
Moderately dry (71-90% exceedance)	996	3,146	5,518	2,150	4,522
Dry (91-100% exceedance)	3,169	7,265	11,559	4,096	8,390

[1] CRDSS Period of Record (Water-years 1909-1998) ranked by gross annual deficits
[2] Net deficits equal gross current/2045 deficits minus gross historic deficits

Table 18. Ability of augmentation volumes to satisfy deficits of fish flow targets at Maybell

Augmentation Volume[1] (AF)	% POR[2] gross deficits satisfied by volume			% POR[2] net deficits[3] satisfied	
	Historic	Current	2045	Current	2045
1,000	84.4%	72.2%	60.0%	78.8%	61.1%
2,000	88.9%	76.7%	70.0%	84.4%	72.2%
3,000	94.4%	80.0%	72.2%	88.9%	73.3%
4,000	96.7%	86.7%	75.6%	95.6%	82.2%
5,000	97.8%	90.0%	82.2%	98.9%	87.8%
6,000	**98.9%**	**94.4%**	**85.6%**	**98.9%**	**90.0%**
7,000	98.9%	96.7%	88.9%	100.0%	91.1%
8,000	98.9%	96.7%	91.1%	100.0%	96.7%
9,000	98.9%	97.8%	91.1%	100.0%	96.7%
10,000	100.0%	98.9%	94.4%	100.0%	98.9%

[1] Not adjusted for transit losses (16.67%)
[2] CRDSS Period of Record (Water-years 1909-1998)
[3] Net deficits equal gross current/2045 deficits minus gross historic deficits

Quantification of Augmentation Needs

A practical approach was needed to determine when river flows should be augmented. Such an approach was developed by the FWS, using set points like a thermostat to turn augmentation on when streamflows fall below a specified lower set point or threshold and turn augmentation off once streamflows reach a specified upper threshold (Figure 13).

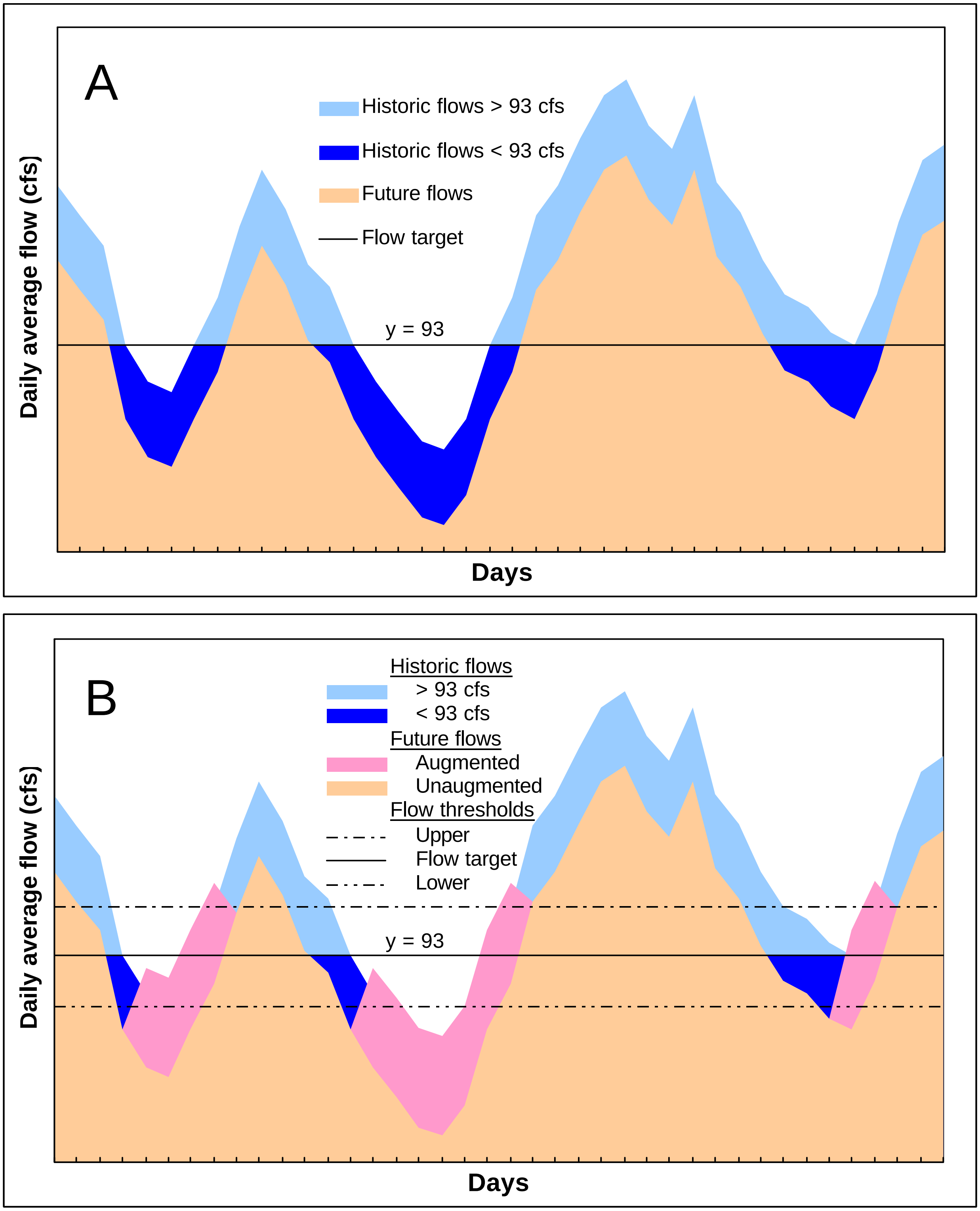

Figure 13. Application of flow thresholds for cuing base flow augmentation in the Yampa River

Graph A depicts hypothetical historic and future hydrographs for the same modeling period. The historic hydrograph (blue) is further differentiated into flows greater than the 93-cfs flows target (light blue) and flows less than 93 cfs (dark blue). In Graph A, the future hydrograph (tan) is unaugmented. Graph B duplicates the two hydrographs in Graph A, but overlays the effects of augmentation (pink) on the future hydrograph. Ideally, flow augmentation should precisely compensate for the difference between future flows and historic flows less than 93 cfs, filling the dark blue area completely. While flow thresholds cannot precisely match, they can closely approximate the historic hydrograph. Granted this is an idealized example. Graph B assumes an immediate and direct effect of augmentation on streamflows. That is, augmented future flows (pink) are the exact sum of unaugmented future flows (tan) plus the volume of augmentation delivered. It does not consider potential lag time or attenuation of delivered flows as a function of distance from their augmentation source(s). But it assumes that sufficient water is provided to offset any transit losses from the source(s) to the point of delivery. Modeling of augmentation volumes used these same assumptions. However, because the effects of lag time and flow attenuation diminish as the duration of augmentation increases, these effects are considered insignificant for modeling purposes.

Flow thresholds bracket the summer/winter flow targets previously described and are applied in accordance with the following protocol:

- When unaugmented streamflows fall below the seasonally appropriate lower threshold, water is released from storage or otherwise provided at a fixed rate until augmented streamflows subsequently exceed the seasonally appropriate upper threshold.
- At that point, augmentation ceases until unaugmented flows again fall below the lower threshold.
- Streamflow augmentation continues throughout the augmentation period (July-March), in accordance with this protocol, or until the available augmentation water supply has been exhausted.

A variety of thresholds and augmentation rates were evaluated using simulated daily flows based on the 90-year CRDSS data to determine which of these augmentation scenarios best simulate historic streamflows and estimate the volume of water needed to satisfy each scenario under a variety of hydrologic conditions.

Thresholds were defined according to three criteria:

1. Flow targets (previously described)
2. Bandwidth - The numerical difference in cfs between upper and lower thresholds regardless of season.
3. Skew - A percentage between +50 % and -50 % multiplied by ½ bandwidth, the net effect of which is to raise or lower both thresholds by the same amount relative to flow targets. At 0 % skew, flow targets are centered between upper and lower thresholds. Magnitudes of any offsets in cfs are proportional to bandwidths.

The effect of increasing bandwidth (at a constant skew) is to delay initiating augmentation and, following onset, to delay its cessation. The effect of positive skew (at a constant bandwidth) is to initiate augmentation earlier and cease augmentation later than with zero skew. Conversely, with negative skew augmentation begins later and ends earlier than under zero skew. If the available volume of augmentation were unconstrained, positive skew would result in more water being released, and negative skew would result in less water being released relative to zero skew.

Three different augmentation rates were selected for each bandwidth, in proportion to bandwidth size. Releases were never more than 90 % bandwidth nor less than 50 % bandwidth. Rates greater than or equal to 100 % were not considered due to their potential to produce a "yo-yo" effect. Rates less than 50 % were not evaluated because at values of skew less than or equal to zero, they failed to achieve flow targets. Therefore, the highest augmentation rates are associated with the largest bandwidths and the lowest rates with the smallest bandwidths. If water supplies were unlimited, more aggressive augmentation scenarios (i.e., positive skew, high augmentation rates) would require larger augmentation volumes than less aggressive strategies. However, if supplies were limited, more aggressive strategies would exhaust supplies earlier and potentially fail to meet augmentation needs later in the season. The following evaluation assumes supplies are limited to 6,000 AF delivered at the Maybell gage.

To compare these scenarios, their efficiencies were calculated as the percentage of net deficits satisfied by each scenario for each year of the CRDSS as follows:

$$1 - \frac{\text{Annual net deficit (augmented)}}{\text{Annual net deficit (unaugmented)}}$$

and expressed as a percentage. If augmented deficits were zero (0), then efficiency would be:

$$1 - \frac{0}{\text{Annual net deficit (unaugmented)}} = 100\%$$

If augmented net deficits were greater than zero, efficiencies would be less than 100 %, and if augmented net deficits were less than zero (i.e., future gross deficits are less than historic gross deficits), efficiencies would be greater than 100 %. Although 100 % is the ideal, it would be unreasonable to expect to meet this every year; nevertheless, efficiencies should approach 100 % as an overall average for the 90-year period of record.

A preliminary assessment of 75 augmentation scenarios revealed that less aggressive scenarios (negative skew <u>and</u> low augmentation rates) failed to meet this objective with greater frequency than did more aggressive scenarios. Ten scenarios spanning a broad spectrum of augmentation criteria were evaluated in detail and ranked based on their relative performance. No one scenario performed better than all the others under all hydrologic conditions. And no scenario performed well under 2045 demand conditions during the driest hydrologic conditions. However, the four best performers satisfied an average 67-70 % of the augmentation need during the period of record under these extreme conditions. Moreover, they met 86-94 % of the augmentation needs under moderately dry hydrologic conditions and 81-96 % under "normal" hydrologic conditions. All four scenarios satisfied an average greater than or equal to 100 % of net deficits under "current" demand conditions for all hydrologic conditions.

One of these four scenarios was selected to evaluate a variety of augmentation water supply alternatives with the CRDSS. This scenario called for the following augmentation criteria: bandwidth = 60 cfs; skew = 50 %; augmentation rate = 50 cfs. These criteria produced lower thresholds of 78 cfs in summer and 109 cfs in winter and upper thresholds of 138 cfs in summer and 169 cfs in winter. These criteria determined when and how much water should be delivered from one or more sources (Table 19). A series of simulations with the CRDSS were used to assess the relative ability of one or more sources to satisfy augmentation needs and to quantify their impacts on the reservoir(s) from which water was delivered. Using the same augmentation scenario, streamflow augmentation "demand" (in AF/month) was calculated and entered into the CRDSS as a contract delivery from storage. At a nominal augmentation rate of 50 cfs delivered at Maybell, a daily volume of about 116 AF (including 16.67% allowance for transit losses) could be delivered for a maximum of 61 days (~7,000 AF/year). The number of days augmentation would be called for during each CRDSS month and year is presented in Table 20. Months following exhaustion of augmentation water supply are shaded, with any unmet demand in parentheses ( ).

This management plan does not dictate any specific flow thresholds or augmentation rates. Using adaptive management, the Recovery Program may set and adjust these variables as it sees fit, within the limits of Colorado water law, operational constraints and availability of augmentation water supplies. The Colorado Water Resources Division will be responsible for shepherding any water released from storage or otherwise provided for augmentation to a delivery point (i.e., Maybell gage and/or other location(s) as determined by mutual agreement of the Recovery Program and State of Colorado).

Tables 19 and 20 show only the 45 years during which some augmentation was required by the selected augmentation protocol. Both tables indicate most (79%) of total annual augmentation is required from August to October, peaking in September (46%), while there is very little demand in November and February, and no demand in March. If water for augmentation were unlimited, the average frequency of augmentation after August would increase, but not significantly. The greatest difference would occur in October, during which frequency of augmentation would increase from 19 years to 27 years, while frequency of augmentation greater than 1,000 AF would increase only from 6 to 8 years, with no increase in frequency of augmentation in excess of 3,000 AF (1 year).

It is also noteworthy that November exhibits less demand than either October or December. This dip in augmentation demand is indicative of the so-called "bounce" or rise in the hydrograph that normally occurs at this time of year. This pattern has been attributed to latent return flows to the river from irrigation earlier in the year (September–October). After the diversions for irrigation cease, it is thought these return flows serve to augment the "natural" hydrograph for a brief period in late autumn. However, the rise in base flows may be a natural phenomenon due to cooler temperatures, the onset of vegetation winter dormancy, and correspondingly lower evapo-transpiration losses.

Table 19. Streamflow augmentation in AF per month as required by protocol

Year at start	Augmentation demand during base flow period[1]									Year at end	AF[2] / Year
	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR		
1913	0	1,273	116	0	0	0	0	0	0	1914	1,389
1915	0	463	579	0	0	0	3,587	2,429	(927)	1916	**7,058**
1931	0	0	2,661	0	0	0	0	0	0	1932	2,661
1933	0	0	2,777	116	0	0	3,587	116	0	1934	6,596
1934	3,587	3,471	(3,587)	(2,314)	(926)	(3,587	(116)	0	0	1935	**7,058**
1935	0	0	3,471	116	0	0	0	0	0	1936	3,587
1936	0	0	3,471	116	231	0	0	0	0	1937	3,818
1937	0	0	579	0	0	0	0	0	0	1938	579
1939	1,041	3,009	1,041	0	0	1,620	347	(1,389)	0	1940	**7,058**
1940	347	3,587	3,124	(463)	0	(579)	0	0	0	1941	**7,058**
1942	0	1,504	3,471	1,273	0	463	0	0	0	1943	6,711
1943	0	0	2,545	116	0	0	3,356	1,041	(116)	1944	**7,058**
1944	0	3,471	3,471	116	(2,545)	0	0	0	0	1945	**7,058**
1946	0	0	3,471	116	0	0	0	0	0	1947	3,587
1948	0	0	3,471	116	0	0	0	0	0	1949	3,587
1949	0	0	463	0	0	0	0	0	0	1950	463
1950	0	926	1,388	0	0	0	0	0	0	1951	2,314
1953	0	0	3,471	1,620	0	0	0	0	0	1954	5,091
1954	0	3,587	1,967	0	0	2	0	6	0	1955	5,562
1955	0	0	3,471	1,273	0	0	0	0	0	1956	4,744
1956	0	0	3,471	3,124	0	0	0	0	0	1957	6,595
1958	0	3,587	3,124	0	0	0	0	0	0	1959	6,711
1959	0	0	1,388	0	0	0	0	0	0	1960	1,388
1960	0	3,587	3,471	(116)	0	0	0	0	0	1961	**7,058**
1961	0	3,587	347	0	0	0	0	0	0	1962	3,934
1962	0	0	3,471	116	0	347	0	0	0	1963	3,934
1963	347	2,083	579	1,851	0	1,041	1,157	(2,546)	0	1964	**7,058**
1964	0	0	1,157	0	0	0	0	0	0	1965	1,157
1966	0	2,777	3,471	231	0	0	0	0	0	1967	6,479
1972	0	1,736	231	0	0	0	0	0	0	1973	1,967
1974	0	116	3,471	116	0	3,355	(348)	0	0	1975	**7,058**
1975	0	0	2,661	116	0	0	0	0	0	1976	2,777
1976	0	0	0	0	926	3,587	2,545	(1,158)	0	1977	**7,058**
1977	2,661	3,587	810	(3,355)	(579)	(2,661	0	0	0	1978	**7,058**
1979	0	0	3,471	116	0	0	0	0	0	1980	3,587
1980	0	0	3,471	926	1,388	1,041	0	0	0	1981	6,826
1981	0	3,587	3,471	(463)	0	0	0	0	0	1982	**7,058**
1988	0	231	1,620	0	0	0	0	0	0	1989	1,851
1989	0	347	3,471	2,545	0	0	0	0	0	1990	6,363
1990	0	3,587	3,471	(116)	0	0	0	0	0	1991	**7,058**
1991	0	0	926	0	0	0	0	0	0	1992	926
1992	0	3,587	3,471	(116)	0	0	0	0	0	1993	**7,058**
1994	2,892	3,587	579	(3,471)	(1,736)	0	0	0	0	1995	**7,058**
1996	0	347	579	0	0	0	0	0	0	1997	926
1998	0	0	579	–	–	–	–	–	–	–	579
AF/mo.	#Years when volume of augmentation > "AF/mo."									AF/year	#Years
> 0	6	24	43	19	3	8	6	4	0	> 0	45
>1,000	4	18	31	6	1	5	5	2	0	>1,000	40
>2,000	3	15	25	2	0	2	4	1	0	>2,000	35
>3,000	1	13	21	1	0	2	3	0	0	>3,000	32
–	–	–	–	–	–	–	–	–	–	>5,000	24
–	–	–	–	–	–	–	–	–	–	>7,000	15

[1] Augmentation year (base flow period) begins July 1 and ends March 31 of the following year.

Table 20. Streamflow augmentation in days per month as required by protocol

Year at start	Augmentation demand during base flow period[1]									Year at end	Days[2]/Year
	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR		
1913	0	11	1	0	0	0	0	0	0	1914	12
1915	0	4	5	0	0	0	31	21	(8)	1916	**61**
1931	0	0	23	0	0	0	0	0	0	1932	23
1933	0	0	24	1	0	0	31	1	0	1934	57
1934	31	30	(31)	(20)	(8)	(31)	(1)	0	0	1935	**61**
1935	0	0	30	1	0	0	0	0	0	1936	31
1936	0	0	30	1	2	0	0	0	0	1937	33
1937	0	0	5	0	0	0	0	0	0	1938	5
1939	9	26	9	0	0	14	3	(12)	0	1940	**61**
1940	3	31	27	(4)	0	(5)	0	0	0	1941	**61**
1942	0	13	30	11	0	4	0	0	0	1943	58
1943	0	0	22	1	0	0	29	9	(1)	1944	**61**
1944	0	30	30	1	(22)	0	0	0	0	1945	**61**
1946	0	0	30	1	0	0	0	0	0	1947	31
1948	0	0	30	1	0	0	0	0	0	1949	31
1949	0	0	4	0	0	0	0	0	0	1950	4
1950	0	8	12	0	0	0	0	0	0	1951	20
1953	0	0	30	14	0	0	0	0	0	1954	44
1954	0	31	17	0	0	2	0	6	0	1955	56
1955	0	0	30	11	0	0	0	0	0	1956	41
1956	0	0	30	27	0	0	0	0	0	1957	57
1958	0	31	27	0	0	0	0	0	0	1959	58
1959	0	0	12	0	0	0	0	0	0	1960	12
1960	0	31	30	(1)	0	0	0	0	0	1961	**61**
1961	0	31	3	0	0	0	0	0	0	1962	34
1962	0	0	30	1	0	3	0	0	0	1963	34
1963	3	18	5	16	0	9	10	(22)	0	1964	**61**
1964	0	0	10	0	0	0	0	0	0	1965	10
1966	0	24	30	2	0	0	0	0	0	1967	56
1972	0	15	2	0	0	0	0	0	0	1973	17
1974	0	1	30	1	0	29	(3)	0	0	1975	**61**
1975	0	0	23	1	0	0	0	0	0	1976	24
1976	0	0	0	0	8	31	22	(10)	0	1977	**61**
1977	23	31	7	(29)	(5)	(23)	0	0	0	1978	**61**
1979	0	0	30	1	0	0	0	0	0	1980	31
1980	0	0	30	8	12	9	0	0	0	1981	59
1981	0	31	30	(4)	0	0	0	0	0	1982	**61**
1988	0	2	14	0	0	0	0	0	0	1989	16
1989	0	3	30	22	0	0	0	0	0	1990	55
1990	0	31	30	(1)	0	0	0	0	0	1991	**61**
1991	0	0	8	0	0	0	0	0	0	1992	8
1992	0	31	30	(1)	0	0	0	0	0	1993	**61**
1994	25	31	5	(30)	(15)	0	0	0	0	1995	**61**
1996	0	3	5	0	0	0	0	0	0	1997	8
1998	0	0	5	–	–	–	–	–	–		5
Days/mo.	#Years when frequency of augmentation ≥ "Days/mo."									Days/yr.	#Years
≥ 1	6	24	43	19	3	8	6	4	0	≥ 1	45
≥10	3	18	30	6	1	3	5	1	0	≥10	40
≥20	3	14	25	2	0	2	4	1	0	≥20	35
≥30	1	12	19	0	0	1	2	0	0	≥30	32
–	–	–	–	–	–	–	–	–	–	≥45	23
–	–	–	–	–	–	–	–	–	–	>60	15

[1] Augmentation year (base flow period) begins July 1 and ends March 31 of the following year.

Formulation of an Augmentation Strategy

A variety of augmentation water supply alternatives were identified and evaluated, including both structural and non-structural options that utilize new and/or existing reservoirs and other existing sources, as practicable. The following sources were evaluated:

- Steamboat Lake (by lease)
- Elkhead Reservoir (by lease, exchange and/or enlargement)
- Stagecoach Reservoir (by lease, exchange and/or enlargement)
- New tributary reservoir(s)
- Other water leases/contracts
- Instream flow water rights

Steamboat Lake

Steamboat Lake is located 26 miles north of Steamboat Springs, Colorado, on Willow Creek, a tributary to the Elk River. It provides both water storage and water-related recreation. It covers roughly 1,100 acres with a total storage capacity of about 26,000 AF, including 18,068 AF for recreation and 5,000 AF for industrial purposes. In addition, up to 3,300 AF is available for instream flow purposes. Currently, the FWS augments Yampa River flows with 2,000 AF from this pool, which it leases from CDPOR. Up to 1,300 AF more water may be leased subject to availability. The entire 3,300 AF has been decreed for instream use, and FWS subleases it to the Colorado Water Conservation Board (CWCB) for this purpose. Water is released from Steamboat Lake at the request of the Recovery Program and CWCB to serve the instream flow needs of the endangered fishes. The Colorado State Engineer delivers the water from Steamboat Lake downstream to the Deerlodge Park gage, less any transit losses. The lease expired on September 30, 1999. However, the FWS and CDPOR are exercising their option to extend the lease for a lease term and price to be negotiated. The source(s) of funding for the lease will depend upon the term of the lease.

Elkhead Reservoir

Elkhead Reservoir is located on Elkhead Creek, a tributary to the Yampa River, about 9 miles northeast of the City of Craig, Colorado. It covers about 500 surface acres. Like Steamboat Lake, Elkhead Reservoir provides both water storage and recreation. Its current capacity of 13,700 AF includes 8,310 AF for industrial purposes, 1,668 AF for municipal purposes and 3,722 AF of dead storage (Hydrosphere 1995). There is no current storage volume available nor allocated to augment stream flows. To create a pool for this purpose in Elkhead, it would be necessary to either enlarge the reservoir or reallocate a portion of the existing pool(s).

Stagecoach Reservoir

This 700-acre reservoir is located on the Yampa River about 16 miles south of Steamboat Springs, Colorado. Its total capacity of 33,275 AF is allocated to industrial (9,000 AF), municipal (7,635 AF) and recreational (16,640 AF) purposes. In addition to these uses, water stored in Stagecoach Reservoir also is used to generate hydro-electric power and to maintain minimum instream flows below the dam (Hydrosphere 1995).

New tributary reservoir(s)

There is no current consensus within the Recovery Program to construct new reservoirs for the sole purpose of augmenting flows for fishes on either a permanent or interim basis. However, the Recovery Program may, on a case-by-case basis, consider the potential impacts and benefits of purchasing water from new storage projects whose primary purpose is to meet human needs. The Recovery Program also will evaluate the trade-offs between potentially greater carriage losses of water released from high-elevation reservoirs versus the potentially greater impacts on peak flows due to storage in low- to mid-elevation reservoirs that minimize carriage losses.

The Colorado River Water Conservation District (CRWCD) identified several candidate sites for construction of small reservoirs to serve human needs (Montgomery Watson 2000). Although this report focused on sites higher on tributaries, the CRWCD (Ray Tenney, CRWCD, personal communication) estimates that sites with sufficient yield to serve the needs of both humans and fish may be found on Fortification Creek, Milk Creek, and Morapos Creek. However, existing hydrologic data for these sites is insufficient to carry out CRDSS analyses.

Fortification Creek originates along the southwestern slopes of the Elkhead Mountains and flows generally south to its confluence with the Yampa River at Craig, Colorado. Draining 34 square miles, the subbasin yielded a 4-year (1956-59) average of about 8,400 AF. CRWCD identified two potential reservoir sites, Rampart Reservoir (Sec. 34, T8N, R90W) and Ralph White (Sec.12, T9N, R91W). Ralph White is the site of an existing breeched dam. Because it is lower in the watershed, its potential yield is greater. However, Rampart has the potential to supplement native inflow. Both suffer from potential sedimentation problems.

Milk Creek arises from the White River Plateau and flows generally north-northwest to its confluence with the Yampa River west of Craig, Colorado. Its watershed covers 65 square miles and yields a 33-year (1953-86) average of about 22,000 AF. CRWCD evaluated several sites on Milk Creek and recommended two for further evaluation: Three Points (Sec. 9, T2N, R81W) and Thornburgh (Sec. 32, T3N, R92W).

Morapos Creek also springs from the White River Plateau, and flows north-northwest to its confluence with the Williams Fork at Hamilton, Colorado, covering 14 square miles and yielding an average of 4,600 AF over 2 years (1966-67). Only one site on Morapos Creek, Monument Butte (Sec. 24, T4N, R92W), was recommended for further evaluation.

Other water leases/contracts

There may be opportunities to lease water from water users in the Yampa River Basin for instream flow purposes. Leases from industrial sources, previously described, and/or supply interruption contracts with irrigators were evaluated to supplement other augmentation sources described above. Any such leases would be pursuant to a consensual agreement and would be fully compensated by the Recovery Program at fair market value. Long-term contracts would provide the greatest benefit for the fishes. However, shorter terms may be considered in the interim until other sources become available.

Instream flow water rights

As a result of concerns expressed by the FWS and other Recovery Program participants, the CWCB withdrew the baseflow and recovery flow instream flow filings on the Colorado and Yampa rivers. With the recent completion of the Colorado River PBO, instream flow water rights to support flow recommendations may not be needed. The Recovery Program Management Committee has agreed that the need for further instream flow filings will be evaluated every 4 years. Therefore, beginning 4 years after a Yampa PBO is completed, the Recovery Program and CWCB will review new flow recommendations of the CDOW and evaluate the performance of this management plan. Upon completion of this review, a determination will be made regarding the need for instream flow protection needs for the endangered fishes. During the final year of the first 4-year period, the Recovery Program and CWCB will develop a process to assess the need for further instream flow protection for endangered fishes.

Description of Alternatives

Eleven alternatives, including “No Action”, were initially identified to provide 7,000 AF of streamflow augmentation. Another alternative was identified as the product of a consensus among a workgroup consisting of local stakeholders and state and federal representatives. The following narrative describes each of the alternatives and the hydrologic assumptions used to model them.

Alternative 1 (No Action): The no action alternative would provide no water to augment streamflows for the endangered fishes.

Alternative 2: Under this alternative, the Recovery Program would draw water first from Steamboat Lake, up to 2,000 AF from the existing pool adjudicated for instream use. When the total volume of releases from Steamboat Lake reaches 2,000 AF, the Recovery Program would begin drawing water from a 3,700-AF pool in Elkhead Reservoir created by an enlargement of the reservoir. For modeling purposes, this pool was assigned the same priority as the California Park water right. Once this pool is exhausted, the Recovery Program would return to Steamboat Lake to release the 1,300-AF balance of the adjudicated instream flow pool.

Alternative 3: This alternative is identical to Alternative 2, except that it requires a 3,700-AF enlargement of Stagecoach Reservoir, rather than Elkhead. This pool would be assigned a new priority, junior to all current water rights but senior to all future water rights. In all other respects, it would operate in the same manner as #2.

Alternative 4: Like Alternatives 2 and 3, Alternative 4 first releases up to 2,000 AF from Steamboat Lake. However, the balance of releases would be made from a 5,000-AF enlargement of Elkhead Reservoir. This pool would be assigned the California Park priority for modeling purposes.

Alternative 5: Similar to Alternative 2, except that the secondary draw on Steamboat Lake would be replaced with a lease of 1,300 AF from the industrial pool of Tri-State Electric Generation & Transmission Cooperative in Stagecoach Reservoir. For modeling purposes, this pool retained its current priority.

Alternative 6: Similar to Alternative 2, except that the secondary draw on Steamboat Lake would be replaced with 1,300 AF from a new tributary reservoir. This alternative cannot be modeled until a specific site for the new reservoir is identified and hydrologic data for the site is compiled.

Alternative 7: This is a non-structural alternative that relies upon existing storage facilities and supply interruption contract(s) to provide water for the fishes. Under this alternative, the primary draw would come from Steamboat Lake (2,000 AF), followed by 1,300 AF from Stagecoach through a lease with Tri-State. Finally, 3,700 AF would be derived from contracts with irrigators who would agree not to divert water from the river they would otherwise be entitled to divert in priority. At this time, no willing irrigators have been identified and no modeling has been done.

Alternative 8: This non-structural alternative relies entirely on Steamboat Lake for the full 7,000-AF augmentation requirement. No enlargement of the reservoir would be necessary. The volume would be taken from the existing 3,300-AF instream flow pool, plus an additional 3,700 AF to be leased from CDPOR out of its existing 18,000-AF recreation pool. Current priorities were used for modeling.

Alternative 9: This alternative relies exclusively on Elkhead Reservoir for 7,000 AF of augmentation. It involves a 3,700-AF enlargement of the reservoir with the balance (3,300 AF) to be derived via an exchange with Steamboat Lake. Under this exchange, 3,300 AF would be reallocated from the 8,310-AF industrial pool to a fish augmentation pool at Elkhead in exchange for reallocating a like volume from the instream flow pool in Steamboat Lake for industrial purposes. This reallocation would reduce the industrial pool in Elkhead to Reservoir 5,010 AF and increase the industrial pool in Steamboat Lake to 8,300 AF. Because transit losses from Steamboat are likely to be greater than from Elkhead, the owner of industrial storage would be compensated for the difference in losses. For modeling purposes, the Steamboat exchange would retain its priority, and the enlargement of Elkhead would be assigned the California Park priority.

Alternative 10: This alternative involves a 7,000-AF enlargement of Elkhead Reservoir to meet the instream flow requirement. This pool was assigned a California Park priority for modeling.

Alternative 11: This non-structural alternative would assign the entire 7,000 AF of augmentation to Stagecoach Reservoir. However, no reservoir enlargement would be necessary. Under this alternative, 3,300 AF would be exchanged between the Steamboat instream flow pool and the Stagecoach industrial pool. In addition, 3,700 AF would be leased from Tri-State's industrial pool in Stagecoach. These pools would retain their respective priorities for modeling.

Consensus (Alternative C)

A workgroup developed a consensus alternative at a conference in Craig, Colorado, August 30-31, 2000 (Appendix C). This workgroup included federal, state and local government representatives; environmental organizations; water users from agricultural, municipal and industrial sectors; landowners; recreational interests; and other stakeholders. Recovery Program participants participated as did members of the Yampa River Basin Partnership, which hosted the conference.

The alternative developed by this workgroup is a hybrid of several of the above alternatives, incorporating elements of Alternatives 4 and 6. This alternative would utilize the lease of 2,000 AF from Steamboat Lake, with the 5,000-AF balance to be delivered from a combination of sources. The source(s) of the 5,000 AF identified by the workgroup included a 3,700-AF enlargement of

Elkhead Reservoir specifically for augmentation with the remaining 1,300 AF to be supplied by a lease of either Tri-State's direct-flow water right for Craig Station or a portion of CRWCD's proposed Elkhead human use pool or new tributary reservoir. Subsequent to the consensus, Tri-State withdrew its offer to lease its direct-flow water right.

Table 21 provides a synopsis of the water supply alternatives considered to provide 7,000-AF for instream flow augmentation purposes. Table 22 depicts the frequency and magnitude of demand served from each of the augmentation water sources under each of 12 alternatives.

Table 21. Streamflow augmentation water supply alternatives: Water source(s) and volume(s)

		No Action	Multiple-source Alternatives							Single-source Alternatives			
	Alternative No.	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**"C"**	**8**	**9**	**10**	**11**
Water Source(s) and Augmentation Volume (acre-feet)	Steamboat Lake lease (1°)		2000	2000	2000	2000	2000	2000		7000			
	Steamboat Lake lease (2°)		1300	1300					2000				
	Elkhead Reservoir enlargement		3700		5000	3700	3700		3700		3700	7000	
	Elkhead Reservoir lease								1300[1]		3300		
	Stagecoach Reservoir enlarge.			3700									
	Stagecoach Reservoir lease					1300		1300					7000
	New tributary reservoir lease						1300		1300[1]				
	Supply interruption contracts							3700					
	Total AF available	0	7000	7000	7000	7000	7000	7000	7000	7000	7000	7000	7000

[1] Lease with CRWCD from Elkhead human use pool (primary) and/or new tributary reservoir (secondary).

Other alternatives considered

Several other options were examined, but eliminated from further evaluation. These options could be used in conjunction with or in lieu of other alternatives: water conservation, supply interruption contracts for the full augmentation volume, and winter storage.

Water conservation potentially could minimize the need for additional storage in the future to meet human needs; however, more "efficient" use of water could have unintended consequences, such as a loss of return flows, impacting riparian and wetland habitats associated with these return flows. Moreover, irrigators should not be coerced to convert from less efficient irrigation methods (flood irrigation) to more efficient methods (e.g., sprinkler irrigation). Economic incentives could be offered for voluntary conversion, but the potential benefits would be difficult to quantify.

Supply interruption contracts with irrigators were considered as a means to provide for the entire volume of augmentation needed (7,000 AF). However, the acreage that would need to be taken out of irrigation was significant, and as native streamflows decline (i.e., when augmentation is needed most) less water would be available from this source. Administration of any foregone deliveries also would be difficult. Alternative 7 would supply up to 3,700 AF from this source, contingent on the availability of willing sellers and a legal mechanism to protect it.

Table 22. Frequency and magnitude of augmentation demand served by 12 water supply alternatives, by water source.

Volume Drawn (AF)	Alternative 1 (No Action)				Alternative 2				Alternative 3				Alternative 4			
	Water Sources: # years needed				Water Sources: # years needed				Water Sources: # years needed				Water Sources: # years needed			
	SB (1)	EH	SB (2)	SC	SB (1)	EH	SB (2)	SC	SB (1)	EH	SB (2)	SC	SB (1)	EH	SB (2)	SC
>0	–	–	–	–	45	35	23	–	45	–	35	32	45	35	–	–
≥500	–	–	–	–	44	34	23	–	44	–	34	28	44	34	–	–
≥1000	–	–	–	–	40	32	18	–	40	–	32	25	40	32	–	–
≥2000	–	–	–	–	35	25	–	–	35	–	–	23	35	25	–	–
≥3000	–	–	–	–	–	24	–	–	–	–	–	23	–	24	–	–
≥5000	–	–	–	–	–	–	–	–	–	–	–	--	–	15	–	–
≥7000	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
MAX AF	–	–	–	–	2,000	3,700	1,300	–	2,000	–	1,300	3,700	2,000	5,000	–	–
AVE AF	–	–	–	–	913	1,177	300	–	913	–	487	989	913	1,510	–	–

Volume Drawn (AF)	Alternative 5				Alternative 6				Alternative 7				Alternative 8			
	Water Sources: # years needed				Water Sources: # years needed				Water Sources: # years needed				Water Sources: # years needed			
	SB (1)	EH	SB (2)	SC	SB (1)	EH	SB (2)	SC	SB (1)	EH	SB (2)	SC	SB (1)	EH	SB (2)	SC
>0	45	35	–	23	45	35	–	–	45	–	–	35	45	–	–	–
≥500	44	34	–	23	44	34	–	–	44	–	–	34	44	–	–	–
≥1000	40	32	–	18	40	32	–	–	40	–	–	32	40	–	–	–
≥2000	35	25	–	–	35	25	–	–	35	–	–	–	35	–	–	–
≥3000	–	24	–	–	–	24	–	–	–	–	–	–	32	–	–	–
≥5000	–	–	–	–	–	15	–	–	–	–	–	–	24	–	–	–
≥7000	–	–	–	–	–	–	–	–	–	–	–	–	15	–	–	–
MAX AF	2,000	3,700	–	1,300	2,000	5,000	–	–	2,000	–	–	1,300	7,000	–	–	–
AVE AF	913	1,177	–	300	913	1,476	–	–	913	–	–	487	2,389	–	–	–

Volume Drawn (AF)	Alternative 9				Alternative 10				Alternative 11				Alternative 12 ("C")			
	Water Sources: # years needed				Water Sources: # years needed				Water Sources: # years needed				Water Sources: # years needed			
	SB (1)	EH	SB (2)	SC	SB (1)	EH	SB (2)	SC	SB (1)	EH	SB (2)	SC	SB (1)	EH	SB (2)	SC
>0	–	45	–	–	–	45	–	–	–	–	–	45		45	24	–
≥500	–	44	–	–	–	44	–	–	–	–	–	44		44	23	–
≥1000	–	40	–	–	–	40	–	–	–	–	–	40		40	23	–
≥2000	–	35	–	–	–	35	–	–	–	–	–	35	–	35	15	–
≥3000	–	32	–	–	–	32	–	–	–	–	–	32	–	32	–	–
≥5000	–	24	–	–	–	24	–	–	–	–	–	24	–	24	–	–
≥7000	–	15	–	–	–	15	–	–	–	–	–	15	–	–	–	–
MAX AF	–	7,000	–	–	–	7,000	–	–	–	–	–	7,000	–	5,000	2,000	–
AVE AF	–	2,389	–	–	–	2,389	–	–	–	–	–	2,389	–	1,907	481	–

Water Sources: SB (1) – Steamboat Lake (primary); SB (2) – Steamboat Lake (secondary); EH – Elkhead Res.; SC – Stagecoach Res.

Number of CRDSS years: 0-10 | 11-15 | 21-30 | 31-40 | 41-50

Winter/off-peak storage could provide all, or a portion of, the 7,000-AF augmentation requirement. Its principal limitations are inadequate hydrology, high cost and potential impacts to winter flows. The winter yield of most tributaries to the Yampa River would not support a volume of this size every year. However, preliminary modeling has shown that in some years storage can begin as early as November, once irrigation is curtailed. Winter storage was specifically considered as an option with an enlargement of Stagecoach Reservoir. Although Stagecoach is situated on the mainstem of the Yampa River, its upstream location limits its usefulness for this purpose similar to that of a tributary. It yields roughly half the volume as measured at the USGS gage at Steamboat Springs. The basins above Steamboat Lake and Elkhead Reservoir cannot provide winter storage without significant impacts to their tailwaters. They also would be less likely to fill during a dry winter, and high demand in the subsequent summer and fall would not be met. One potential, though expensive, option would be to divert water from the mainstem of the Yampa into a tributary reservoir, such as Elkhead. This option would require construction of a lengthy pipeline/canal to deliver water to the reservoir. Moreover, it poses potential impacts to base flows that could preclude satisfaction of the FWS winter flow recommendation of 124 cfs.

Evaluation of Alternatives

Each of the 12 alternatives (1-11, plus the consensus alternative, "C") was subjected to a preliminary feasibility analysis, using the following evaluation criteria: (1) ability to meet augmentation needs; (2) estimated cost; (3) impacts on Colorado State Parks and water-related recreation; (4) impacts on agriculture; and (5) impacts on peak flows.

Using CRDSS, end-of-month (EOM) values were estimated for total reservoir contents, endangered fish account contents (a subset of total contents), water surface elevation, water surface area, and water released to serve fish demand. These EOM data were further analyzed to determine the hydrologic effectiveness or reliability of each alternative in meeting augmentation requirements of the fishes. In addition, EOM reservoir elevations and surface areas were used to assess impacts to Colorado State Parks and water-related recreation at Steamboat, Elkhead and Stagecoach reservoirs.

<u>Ability to meet augmentation needs</u>

To determine their reliability, the CRDSS produced estimates of EOM volumes of water released for fish for each of eight alternatives (#s 2-5 and 8-11). CRDSS data was formatted on a water-year basis. However, for this analysis data were reformatted on an "augmentation-year" basis (July-March), with reservoirs refilling during the subsequent spring runoff period (April-June). The annual sum of releases for fish during the augmentation year were compared against fish demand during the same period to determine the performance of each alternative. For analytical purposes, Alternative "C" is considered to be similar in performance to Alternative 4.

Because the No Action Alternative (#1) would provide no water for the fishes, it cannot satisfy any demand. Alternative 6 was not modeled because there is no site-specific hydrologic data yet available for many of the potential new reservoir sites. Alternative 7 was not modeled, because point(s) of diversion, volume(s) of water available and priority of water rights vary between different irrigators and, therefore, its underlying hydrologic assumptions will depend upon which, if any, irrigator(s) would be willing to enter into supply interruption contracts. However, because water demands for fish would be greatest in the driest years, this alternative is likely to fall short of demand with greater frequency and magnitude than reservoir storage alternatives (see further discussion of **Alternative 7** under <u>Impacts on agriculture</u> on Page 71).

Alternatives 9 and 10, which relied solely on Elkhead Reservoir (7,000 AF), and Alternative 5, which used Steamboat (2,000 AF), Elkhead (3,700 AF) and Stagecoach (1,300 AF), performed the best in terms of reliability. There were no shortages in any of the 45 years during which water was required by the augmentation protocol. Alternative 8, which relied solely on Steamboat Lake, performed the worst, suffering augmentation shortages in 13 of 45 years, with a maximum shortage of more than 6,000 AF. This occurred in 1977, the driest year on record, when the augmentation protocol called for the maximum volume, following another dry year (1976) when the maximum volume of augmentation was delivered per protocol. However, shortages in the 12 remaining years were less than 500 AF/year with this alternative. The remaining alternatives modeled (2, 3, 4/C and 11) ranked fourth, seventh, fifth, and sixth, respectively, but only Alternative 3 had any shortages greater than 500 AF (in only 2 of 45 years), with a maximum shortage of 546 AF.

<u>Comparison of estimated costs</u>

Costs were estimated for each alternative using $1,800/AF for new reservoir storage (including enlargements of existing reservoirs) and $35/AF/year to lease water during a 45-year planning horizon ($35/AF/year x 45 years = $1,575/AF). This lease rate is for comparison purposes only. Actual lease rates would be negotiated with willing lessors based on the fair market value of water in consideration of other terms and conditions of the lease(s). To estimate the present value of leases, a discount rate of 6% was applied, yielding a capitalized unit lease cost of $573/AF (Table 23). Table 24 provides a summary of the total estimated cost of the alternatives. Legal and other costs related to adjudicating water rights were not included in these estimates.

Table 23. Estimation of lease costs* for Yampa River augmentation water supply alternatives

	Leased Volume	Annualized costs $35/AF/yr x 45 yrs		Capitalized costs (%Discount Rate) 5%		6%		7%		8%	
Alt.#s	(AF)	$/AF	Total $	$/AF	Total $	$/AF	Total $	$/AF	Total $	$/AF	Total $
1,10	-	-	-	-	-	-	-	-	-	-	-
4,6	2,000	**1,575**	**3,150,000**	653	1,306,394	**573**	**1,146,823**	510	1,019,054	458	915,395
2,3,5,9,C	3,300	**1,575**	**5,197,500**	653	2,155,550	**573**	**1,892,258**	510	1,681,438	458	1,510,402
7,8,11	7,000	**1,575**	**11,025,000**	653	4,572,379	**573**	**4,013,880**	510	3,566,687	458	3,203,883

* Costs in bold text were used in comparison of alternatives.

Table 24. Estimated costs* of Yampa River augmentation water supply alternatives

	New storage @$1800/AF constructed		With total annual lease costs @$35/AF/year for 45 years: Lease(s)			Total	With lease costs capitalized based on 6% discount rate: Lease(s)			Total
Alt.#s	AF	x$1000	AF	$/AF	x$1000	x$1000	AF	$/AF	x$1000	x$1000
1	-	-	-	-	-	-	-	-	-	-
7,8,11	-	-	7,000	1,575	11,025	11,025	7,000	573	4,014	4,014
2,3,5,9,C	3,700	6,660	3,300	1,575	5,198	11,858	3,300	573	1,892	8,552
4,6	5,000	9,000	2,000	1,575	3,150	12,150	2,000	573	1,147	10,147
10	7,000	12,600	-	-	-	12,600	-	-	-	12,600

* Alternatives are grouped and ranked from least expensive to most expensive.

Alternative 1 does not provide any augmentation; therefore, its augmentation costs are zero. Alternative 10 is totally dependent upon new storage. Because unit costs to construct new storage are higher than those of leases, whether annualized or capitalized, Alternative 10 is the most expensive option at $12.6 million. Conversely, because they rely entirely on leases, Alternatives 7, 8 and 11 are least expensive at $11,025,000 ($4,014,000 if lease costs are capitalized at a 6% discount) based on a unit lease cost of $35/AF/year. The remaining alternatives (#s 2, 3, 4, 5, 6, 9 and "C") combine new storage with leases; to determine their total costs, their lease costs were added to their construction costs. Their relative cost varies in proportion to the volume of new storage versus the volume of leased water (Table 24).

<u>Impacts to Colorado State Parks and water-related recreation</u>

Impacts to park facilities and water-related recreation are discussed below for each of the three reservoirs and seven alternatives modeled. The CDPOR provided a specific threshold of changes in water surface elevation for Steamboat Lake by which to compare the alternatives. This threshold was two feet, and serves as the basis for the existing lease of 2,000 AF. This same threshold was also applied to Elkhead and Stagecoach, although the sensitivity to such changes may be greater at Steamboat due to the shallowness of its basin. Moreover, CDPOR recommended that impacts to its parks and water-related recreation should be minimized during the summer peak-use period (i.e., through September 15). The tiered use of the Steamboat Lake 3,300-AF instream flow pool in Alternatives 2 and 3 attempts to comply with this recommendation.

However, the monthly CRDSS output does not allow for that level of precision. Nevertheless, estimates of mid-month surface elevations and reservoir areas were derived by averaging August and September EOM data. In addition, separate criteria were developed for reservoir surface area as another means to evaluate alternatives.

Moreover, a preliminary assessment indicated that reservoir levels occasionally fluctuated more than two feet even when there were no releases for fish. To segregate those impacts, the analysis focused on months in which releases were made for fish. To further refine this estimate, EOM differential values of elevation and surface area were multiplied by a factor equal to the difference in the EOM fish pool contents divided by the difference in the EOM reservoir contents to determine that portion of the elevation/area change for which releases from the fish pool(s) were responsible (Table 25).

Alternative 1: The No Action alternative assumes no storage of water for fish; therefore, there would be no impacts to park facilities or water-related recreation.

Alternative 2: Steamboat Lake would experience elevation changes greater than 2 feet in 11 out of 48 years, with a maximum loss of 2.7 feet. However, prior to September 15 only 1 year in 48 experienced a loss greater than 2 feet (2.2 feet). Steamboat Lake would experience no losses of surface acreage greater than 10% before or after September 15 (8% maximum).

Elkhead Reservoir would gain 7.6 feet elevation due to a 3,700-AF enlargement. It would experience losses in elevation greater than 2 feet in 36 years (32 years prior to September 15), with maximum losses of 11.7 and 7.7 feet, respectively. Surface acreage would increase by 64 acres due to enlargement and suffer losses greater than 10% in 25 years (18% maximum), 12 years prior to September 15 (12% maximum).

Table 25. Streamflow augmentation water supply alternatives: Reservoir sensitivity analyses

			Multiple-source Alternatives							Single-source Alternatives			
		Alternative No.	**2**	**3**	**4**	**5**	**6**	**7**	**"C"**	**8**	**9**	**10**	**11**
Adjusted Reservoir Elevation[1]	**Steamboat**	Maximum WSEL[2] lost before 9/15	-2.2	-2.4	**-1.9**	**-1.9**	Similar to Alternative 5	Similar to Alternative 5	Similar to Alternative 4	-6.2			
		#Yrs w/losses > 2 ft. before 9/15	1	2	**0**	**0**				16			
		Maximum annual WSEL[2] lost	-2.7	-2.7	**-1.9**	**-1.9**				-6.8			
		#Years w/annual losses > 2 ft.	12	7	**0**	**0**				34			
	Elkhead	Enlargement (elevation gain)	7.6		10.1	7.6	Similar to Alternative 5		Similar to Alternative 4		7.6	13.8	
		Maximum WSEL[2] lost before 9/15	-7.7		-8.3	**-7.3**					-12.0	-10.7	
		#Yrs w/losses > 2 ft. before 9/15	32		15	**11**					32	32	
		Maximum annual WSEL[2] lost	-11.7		-8.3	**-7.3**					-13.0	-11.4	
		#Years w/annual losses > 2 ft.	36		29	**21**					37	36	
	Stagecoach	Enlargement (elevation gain)		4.4		0.0		Larger and more frequent than #5					0.0
		Maximum WSEL[2] lost before 9/15		-7.2		**-1.2**							-14.2
		#Yrs w/losses > 2ft. before 9/15		27		**0**							17
		Maximum annual WSEL[2] lost		-7.2		**-1.2**							-14.2
		#Years w/annual losses > 2ft.		36		**0**							29
Adjusted Reservoir Surface Area[1]	**Steamboat**	Maximum acres lost before 9/15	-78.1	-84.8	-61.7	**-61.5**	Similar to Alternative 5	Similar to Alternative 5	Similar to Alternative 4	-209.7			
		Maximum % area lost before 9/15	7%	8%	5%	**5%**				19%			
		#Yrs w/losses > 10% before 9/15	**0**	**0**	**0**	**0**				13			
		Maximum annual acreage lost	-89.6	-97.2	**-63.7**	-64.3				-224.4			
		Maximum annual % area lost	8%	9%	**6%**	6%				20%			
		#Years w/annual losses > 10%	**0**	**0**	**0**	**0**				27			
	Elkhead	Enlargement (additional acres)	64.4		85.7	64.4	Similar to Alternative 5		Similar to Alternative 4		64.4	116.9	
		Maximum acres lost before 9/15	-69.0		-77.4	**-61.7**					-107.5	-94.2	
		Maximum % area lost before 9/15	12%		13%	**11%**					19%	15%	
		#Yrs w/losses > 10% before 9/15	12		**1**	**1**					14	12	
		Maximum annual acreage lost	-98.9		-84.1	**-64.2**					-134.7	-119.8	
		Maximum annual % area lost	18%		14%	**11%**					24%	19%	
		#Years w/annual losses > 10%	25		16	**9**					27	21	
	Stagecoach	Enlargement (additional acres)		45.1		0.0		Larger and more frequent than #5					0.0
		Maximum acres lost before 9/15		-75.5		**-16.0**							-132.6
		Maximum % area lost before 9/15		10%		**2%**							19%
		#Yrs w/losses > 10% before 9/15		1		**0**							7
		Maximum annual acreage lost		-92.7		**-19.8**							-141.5
		Maximum annual % area lost		12%		**3%**							20%
		#Years w/annual losses > 10%		4		**0**							12

[1] Adjusted to isolate reservoir releases attributable to augmentation. **Bold** values represent least impact.
[2] WSEL = water surface elevation

Alternative 3: Steamboat Lake would experience elevation changes greater than 2 feet in 7 out of 48 years, with a maximum loss of 2.7 feet. However, prior to September 15 only 2 years in 48 experienced a loss greater than 2 feet (2.4 feet). Steamboat Lake would experience no losses of surface acreage greater than 10% before or after September 15 (9% maximum).

Stagecoach Reservoir would gain 4.4 feet elevation due to a 3,700-AF enlargement. It would experience losses in elevation greater than 2 feet in 36 years (27 years prior to September 15), with maximum losses of 7.2 feet before or after September 15. Surface acreage would increase by 45 acres due to enlargement and suffer losses greater than 10% in 4 years (12% maximum), but only 1 year prior to September 15.

Alternative 4: Because the draw on Steamboat Lake is limited to 2,000 AF with this alternative, it would experience no elevation changes greater than 2 feet in any year, with a maximum loss of only 1.9 feet. Moreover, Steamboat Lake would experience no losses of surface acreage greater than 10% before or after September 15 (6% maximum).

Elkhead Reservoir would gain 10.1 feet elevation due to a 5,000-AF enlargement. It would experience losses in elevation greater than 2 feet in 29 years (15 years prior to September 15), with maximum losses of 8.3 feet before or after September 15. Surface acreage would increase by 86 acres due to the enlargement and suffer losses greater than 10% in 10 years (13% maximum), but only 1 year prior to September 15.

Alternative 5: As expected, this alternative performs about the same as Alternative 4 in terms of its impact on Steamboat Lake. Frequency and magnitude of changes in both reservoir elevation and surface area are comparable. This alternative performs somewhat better than Alternative 4 in terms of its impacts on Elkhead Reservoir. Elkhead Reservoir would gain 7.6 feet elevation due to a 3,700-AF enlargement. It would experience losses in elevation greater than 2 feet in 21 years (11 years prior to September 15), with maximum losses of 7.3 feet before or after September 15. Surface acreage would increase by 64 acres due to enlargement and suffer losses greater than 10% in 7 years (11% maximum), but only 1 year prior to September 15.

Of all the alternatives that utilize Stagecoach Reservoir, this has the least impact to Stagecoach. Stagecoach Reservoir would not be enlarged with this alternative, so neither elevation nor area would increase. Moreover, it utilizes only 1,300 AF from Stagecoach, compared with 3,700 AF with Alternative 3 and 7,000 AF with Alternative 11. Losses in elevation would not exceed 2 feet (1.2 feet maximum), and areal losses would not exceed 10% (3% maximum), before or after September 15.

Alternative 6: Not modeled. However, impacts to Steamboat Lake should be similar to those of Alternatives 4 and 5; impacts to Elkhead Reservoir should be similar to those of Alternative 2. Impacts to unidentified new tributary reservoir(s) were not modeled nor estimated.

Alternative 7: Not modeled. However, impacts to Steamboat Lake should be similar to those of Alternatives 4 and 5. Because this alternative would release 1,300 AF of water from Stagecoach as the second priority source (versus third priority with Alternative 5), frequency and magnitude of impacts to Stagecoach Reservoir should be greater than those of Alternative 5, but less than those of Alternatives 2 and 11, which would release up to 3,700 AF and 7,000 AF, respectively.

Alternative 8: As expected, alternatives that rely entirely on a single reservoir have a far greater impact on that reservoir than do alternatives where demand is distributed across several sources. In this case, Steamboat Lake suffers losses in elevation greater than 2 feet in 34 of 48 years (6.8 feet maximum), and 16 of 48 years prior to September 15 (6.2 feet maximum). Similarly, losses in surface acreage are significant, exceeding 10% in 27 years (20% maximum), 13 years prior to September 15 (19% maximum).

Alternative 9: Although a 3,700-AF enlargement of Elkhead results in increases of only 7.6 feet in maximum reservoir elevation and 64 acres in reservoir surface area, impacts on elevation and acreage are proportional to the entire 7,000-AF volume of the fish pool. Elevation losses exceed 2 feet in 37 years (13 feet maximum), 32 years prior to September 15 (12 feet maximum), while areal losses exceed 10% in 27 years (24% maximum), 13 years prior to September 15 (19% maximum).

Alternative 10: While a 7,000-AF enlargement of Elkhead will raise its maximum elevation by 13.8 feet and increase its surface area by 117 acres, the larger size of the reservoir compared to Alternative 9 serves to slightly attenuate impacts to elevation and area. Losses in elevation would exceed 2 feet in 36 years (11.4 feet maximum), 32 years prior to September 15 (10.7 feet maximum), while areal losses would exceed 10% in 21 years (19% maximum), 12 years prior to September 15 (15% maximum).

Alternative 11: Stagecoach Reservoir would not be enlarged with this alternative, so neither elevation nor area would increase. However, significant impacts to elevation and area would result from drawing the entire 7,000-AF fish account from this reservoir. Losses in elevation would exceed 2 feet in 29 years, 17 years prior to September 15 (14.2 feet maximum). This is the largest loss of reservoir elevation for any alternative. Areal losses would exceed 10% in 12 years (20% maximum); however, the maximum loss in acreage (141.5 acres) also is greater than with any other alternative.

Alternative "C": This alternative is similar to Alternative 4 in that impacts are restricted to Steamboat Lake and Elkhead Reservoir in roughly the same magnitude. Unlike Alternative 4, however, a portion of the volume derived from Elkhead Reservoir (1,300 AF) may be provided by a new tributary reservoir in the future. This would reduce impacts to Elkhead to the same levels as Alternative 6. Impacts also would result to any new reservoir from which water is delivered.

<u>Impacts on agriculture</u>

Alternative 7: Because this alternative would utilize up to 3,700 AF of irrigation water to meet the instream flow targets for fish, there could be an adverse impact on agriculture. However, this alternative would call upon source(s) of irrigation water as the last priority, only after all water leased from both Steamboat Lake (2,000 AF) and Stagecoach Reservoir (1,300 AF) is exhausted. Therefore, water from agriculture would be needed in only 29 years of the 90-year CRDSS record (i.e., when water demand for fish exceeds 3,300 AF/year). Moreover, the full 3,700 AF from this source would be needed in only 13 years. However, in 10 of the 29 years the demand for water from this source extends beyond October. Therefore, in those years, some portion of this demand would not be satisfied, because irrigation normally ends in October (Table 26). This shortcoming could be partly ameliorated if this source were called upon before Steamboat or Stagecoach. However, the impacts to agriculture in this case could be unacceptable, not only because larger volumes would be required from this source, but also water would be needed earlier during the irrigation season.

Table 26. Estimated frequency and magnitude of fish demand for irrigation water supply

Estimated volume of fish demand	Number of years[1] needed by end of month					#Years unmet[2]
	JUL	AUG	SEP	OCT	MAR	
>0 AF	0	13	26	26	29	10
>1000 AF	0	3	15	20	24	7
>2000 AF	0	3	12	14	21	5
>3000 AF	0	1	10	12	18	4
=3700 AF	0	0	8	9	13	2

[1] Out of 90 years of the CRDSS record

[2] Frequency of shortages by volume due to unsatisfied post-irrigation fish demands.

All other alternatives: Because the priorities of most water rights proposed to augment streamflows are junior to current agricultural water rights, the impact of streamflow augmentation on irrigation overall should be minor.

Impacts on peak flows

All of the alternatives except Alternative 1 (No Action) rely on reservoir storage to meet at least a portion of augmentation demand for fish. Because reservoirs would augment during base flow periods (mid-July to mid-March) and principally store water during peak flow periods (mid-March to mid-July), these alternatives would have some impact on peak flows. However, the nature and magnitude of the impact would vary with the volume(s) and location(s) of storage. In this case, it does not matter whether water is delivered from a lease of existing storage or from a new or enlarged reservoir; the impact would be identical for the same volume and location of storage.

The timing of impacts also is important. The highest peak flows are considered most important, while the ascending and descending limb, though important, are not as critical. Elkhead Creek generally peaks earlier than the mainstem of the Yampa River. Therefore, Elkhead Reservoir would store water on the ascending limb of the Yampa River. Steamboat Lake and Stagecoach Reservoir are higher in the basin and store water closer to the peak of the mainstem. The impacts of a new tributary reservoir (Alternative 6) cannot be assessed until a specific design capacity and location are identified. Irrigation supply interruption contracts (Alternative 7) may or may not impact peak flows, depending on whether these diversions are supported by reservoir storage. Direct-flow water rights, without reservoir storage, would not impact peak flows to the same extent.

On average, peak flows ranging from 6,000 to 12,000 cubic feet per second (cfs) occur at Maybell 56 out of 83 years (67%) with an average recurrence interval of 1.5 years (Figure 14). Peak flows greater than 12,000 cfs occur in 9/83 years (11%), while peaks less than 6,000 cfs occur in 18/83 years (22%). The highest flow ever recorded at the Maybell gage was 24,400 cfs on May 17, 1984, while the lowest peak flows of 3,180 cfs were recorded at Maybell on June 5 and June 10, 1977. Spring runoff typically begins in mid-March and wanes by mid-July. Transient flow maxima at Maybell generally occurred sometime between late April and mid-June (Figure 15); however, more than 60% (57/94 occurrences) of these maxima occurred within a 3-week period (May 10–31), during which more than one-fourth of the average annual discharge passes the Maybell gage.

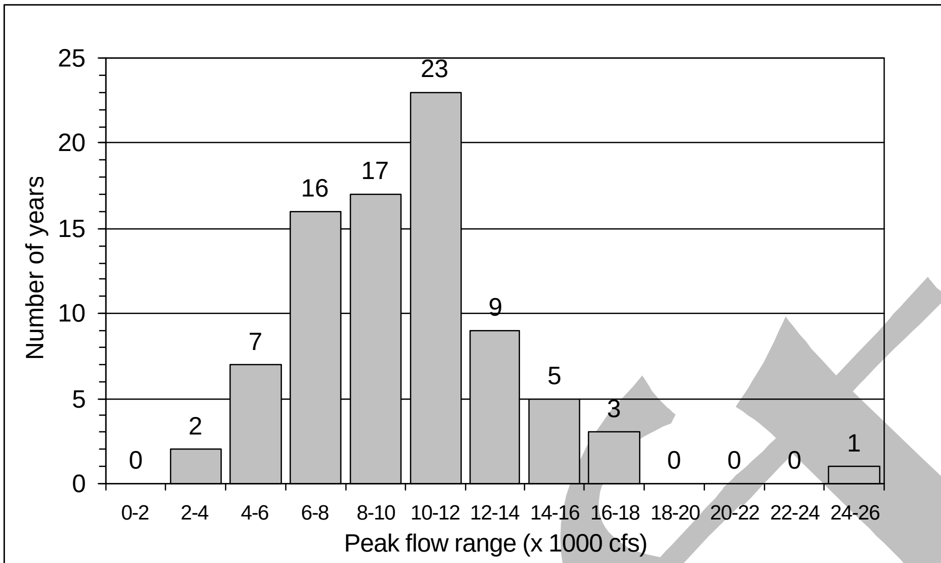

Figure 14. Magnitude and relative frequency of annual flow maxima ($N = 83$) at the Maybell gage (1916-1998).

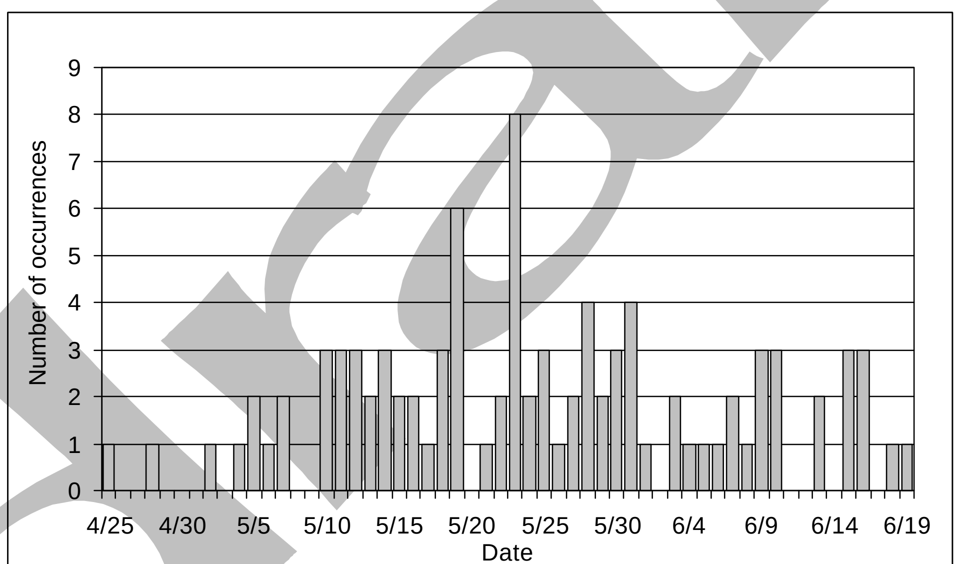

Figure 15. Temporal distribution of annual flow maxima ($N = 94$) at the Maybell gage (1916-1998).

With this background, a preliminary analysis was carried out using end-of-month (EOM) reservoir contents and "fish pool" contents, which is a subset of total reservoir contents. These contents are expressed in acre-feet. Changes in contents between months were calculated and converted to average monthly flows in cubic feet per second. A positive number represents a gain in reservoir volume (i.e., storage), with a commensurate loss of streamflow downstream from the reservoir. Negative numbers result when reservoir outflows exceed inflows (i.e., releases are being made from storage), with a commensurate increase in streamflows. To determine the peak change in stream flows resulting from storage and release of water from storage, actual peak flows at the Maybell gage during the historical record (1916-1998) were correlated with their corresponding total monthly discharges. These data correlated with a coefficient of 0.95, where 1.00 is the highest possible correlation. Peak daily flows were then divided by the average daily flows (total monthly discharge) during the same months in which the peak flows occurred. The average of these calculated values for the entire period of record at Maybell is 1.5, with a standard deviation of 0.17. On this basis, changes in modeled average daily flows were multiplied by 1.5 to estimate changes in peak flows for each of the action alternatives modeled (Table 27). Average monthly flow values can be computed by multiplying peak flow values in Table 27 by two-thirds.

Contents of reservoirs fluctuate, due to evaporative losses, even when no augmentation demand is placed on them. The amount of evaporation is assigned to each reservoir account in proportion to its contents. These fluctuations are expressed as small, relatively constant values of change in fish pool contents in most months, regardless of augmentation demand or whether the augmentation water supply came from a lease or an enlargement. To differentiate losses in reservoir contents due to evaporation from those due to augmentation, month-specific "filters" in cfs, as shown below, were applied to each alternative to reduce changes in stream flow by the amount of evaporation.

Alt. #	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN
2	1	1	1	1	1	1	1	1	1	3	3	1
3	3	2	7	4	2	2	2	1	3	4	4	1
4	1	2	6	2	1	1	1	1	7	7	6	1
5	1	1	6	2	1	1	1	1	7	7	5	1
8	2	1	11	1	1	1	1	1	10	7	10	1
9	1	1	2	1	1	1	1	1	1	1	1	1
10	1	1	1	2	1	1	1	1	1	1	1	1
11	3	1	3	3	1	1	1	1	1	1	1	1

The effect of these filters was to reduce values greater than zero and increase values less than zero by the amount of the filters. However, if the absolute value of flow was less than the filter value, the flow value was reduced or increased to zero, thereby eliminating the 45 years in which evaporation alone produced a gain or loss in one or more months. Without these filters, evaporative losses would have appeared as a "gain" in streamflow, while storing water to make up for evaporation would have appeared as a "loss" in streamflow.

Data are displayed in Table 27 to highlight the differences between alternatives. For comparison purposes, multiple-source alternatives 2-5 are shown together in Table 27a, while single-source alternatives 8-11 are grouped in Table 27b. Months during which stream flows increased (i.e., augmentation) are shown in shades of blue, growing more intense in color as flows increase. Conversely, reductions in stream flow (i.e., reservoir storage) are displayed in warm colors ranging from yellow to red as the rate of reservoir storage increases, with a commensurate decline in stream flows downstream from the reservoir(s). The number within each cell represents the number of CRDSS years for that month that exceed a certain change in flow (cfs), whether increasing or decreasing. The number of years that exceed zero represent the total number of years in which augmentation/storage occurs. The numbers down each columns are not additive, but cumulative; that is, months during which the rate of change in fish pool contents exceeds 100 cfs are nested within those exceeding 50 cfs, which in turn are nested within those exceeding 20 cfs, and so forth.

Table 27a. Comparison of augmentation water supply alternatives: Peak flow [1] impacts

		Flow (cfs)	Number of CRDSS years in which peak change in flow is exceeded											
			JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN
Alternative 2	Gains	>100												
		>50	2	14	24	1		2	1					
		>20	3	17	30	4	1	3	4					
		>10	3	19	36	4	1	5	5					
		>0	6	23	41	11	1	6	5	2				
	Losses	>0			2	26	18	23	22	21	20	11	19	
		>10			1	18	15	13	15	15	16	9	17	
		>20				12	6	7	10	8	13	7	15	
		>50				1					5	4	10	
		>100												
Alternative 3	Gains	>100												
		>50	1	13	22			2	1					
		>20	4	19	27	2		2	4					
		>10	4	19	31	2	1	4	4					
		>0	7	26	35	3	1	5	5	2				
	Losses	>0			3	37	35	25	21	26	22	24	21	10
		>10			2	25	13	3	2	4	3	12	14	
		>20			1	19	2		1	1	1	4	12	
		>50				5							8	
		>100												
Alternative 4	Gains	>100												
		>50	2	14	24	1		2	1					
		>20	4	19	30	3	2	3	4					
		>10	6	19	33	4	2	5	5	1				
		>0	7	26	38	5	2	6	5	2				
	Losses	>0			1	18	13	15	21	19	12	15	36	1
		>10				12	10	10	16	13	10	12	35	
		>20				7	2	7	10	8	8	10	33	
		>50									1	3		
		>100												
Alternative 5	Gains	>100												
		>50		9	8	1		1	1					
		>20	4	19	30	3	2	5	3					
		>10	6	20	34	5	2	5	4					
		>0	7	26	38	5	2	6	4	2				
	Losses	>0			1	13	14	12	16	15	10	12	37	
		>10				9	6	10	9	8	6	11	35	
		>20				6	2	6	5	3	4	9	33	
		>50										2		
		>100												

[1] Runoff months are shaded gray

Table 27b. Comparison of augmentation water supply alternatives: Peak flow [1] impacts

		Flow (cfs)	Number of CRDSS years in which peak change in flow is exceeded											
			JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN
Alternative 8	Gains	>100												
		>50	2	15	23	2		2	1					
		>20	3	18	29	5	2	5	4					
		>10	6	19	32	5	2	5	5	2				
		>0	7	25	36	19	2	7	5	3				
	Losses	>0										9	39	6
		>10										8	38	4
		>20										7	36	4
		>50										2	30	2
		>100											18	
		>150											8	
		>200												
Alternative 9	Gains	>100												
		>50	2	14	24	1		2	1					
		>20	3	17	30	4	1	3	4					
		>10	3	19	36	5	1	5	5					
		>0	10	23	38	11	1	6	5	2				
	Losses	>0			2	29	18	25	22	26	26	14	1	
		>10				19	13	16	17	19	24	14	1	
		>20				13	5	7	9	14	19	11		
		>50				1				1	11	8		
		>100										4		
		>150												
Alternative 10	Gains	**>100**												
		>50	2	15	24	1		2	1					
		>20	3	17	29	3	1	3	4					
		>10	3	19	36	4	1	5	5					
		>0	4	22	39	5	1	6	5	2				
	Losses	>0		1	2	28	18	24	22	25	26	12	1	
		>10			1	17	15	13	16	20	22	10		
		>20				11	6	7	11	14	17	9		
		>50				1				1	9	8		
		>100										4		
		>150												
Alternative 11	Gains	>100												
		>50	1	11	12			1	1					
		>20	3	16	21	1		2	4					
		>10	4	16	29	2	1	4	5					
		>0	7	23	34	3	2	5	5	2				
	Losses	>0	1	4	6	34	34	21	18	20	20	23	19	10
		>10			2	23	15	10	7	6	14	19	11	2
		>20			1	16	4		1	2	1	7	3	
		>50			1									
		>100												

[1] Runoff months are shaded gray

These data show that augmentation can occur in any month from July through February. August and September are augmented most frequently, peaking in September, while February is rarely augmented. Note that the maximum amount of augmentation in any month is constrained to 50 cfs by the augmentation protocol. However, because the same multiplier of 1.5 was applied to both storage <u>and</u> augmentation, the maximum value of augmentation can be as high as 75 cfs.

Conversely, storage can begin as early as September, but more commonly begins in October once irrigation ceases. For most alternatives, storage is generally highest during the months of March through May, peaking in April, and rarely lasting into June (and in one case, July). Notable exceptions are Alternative 8, Steamboat Lake only, in which most storage occurs in May, and Alternative 11, Stagecoach Reservoir only, that stores most often in October. Although Steamboat Lake and Stagecoach Reservoir are located high in the basin (8,000 and 7,200 feet elevation, respectively), the watershed above Steamboat Lake is not large enough to produce reliable inflows year-round. Stagecoach is on the mainstem of the Yampa, though the Yampa at this point is no larger than a significant tributary. However, its basin is large enough to support fall-winter storage in some years.

Elkhead-only (9-10) and multiple-source (2-5) options are somewhat intermediate between single-source alternatives Steamboat (8) and Stagecoach (11) in which months they store water. Because Elkhead stores early on the peak, it is generally full by the end of April. This pattern is reflected in the two Elkhead-only options. Because each of the multiple-source alternatives relies on Steamboat Lake to a certain extent (2,000-3,300 AF), storage for these alternatives is skewed somewhat toward May, but less so than Steamboat alone. For this analysis, the Consensus alternative would perform much like Alternative 4.

In summary, differences between single-source alternatives are most dramatic. Steamboat Lake has the greatest impact on peak flows, because peak storage occurs in May, which coincides with peak runoff. Stagecoach Reservoir distributes storage more evenly from October through May. Elkhead stores from October through April, but is more biased toward April. Multiple-source alternatives are more difficult to distinguish, except that Steamboat Lake, the primary source of each of these alternatives, throws some bias toward the spring.

Nevertheless, with the exception of the Steamboat only option (Alternative 8), impacts to peak flows rarely exceed 50 cfs, which is a small fraction (1.6%) of even the lowest peak flows, and 0.2% of the highest peak flow. Three alternatives (8-10) exceed 100 cfs, and only one of these (8) exceeds 150 cfs. Alternatives 9 and 10, Elkhead only, exceed 100 cfs in 4 of 90 years, while Alternative 8 exceeds 100 cfs in only 20% of years. At 100 cfs, the percentage loss doubles (3.2% and 0.4% for lowest and highest peaks, respectively). During a median peak flow year (~10,000 cfs), the impact of 100 cfs would be about a 1.0% reduction in peak flows, and that would occur infrequently even under the worst-case scenario.

Restore Habitat (Habitat Development and Maintenance)

Restore and Manage Flooded Bottomland Habitat

Bottomlands in the lower-gradient reaches of the Middle Green River (Jensen to Ouray, Utah) provide, or have the potential to provide, important nursery habitats for the Colorado pikeminnow and razorback sucker. These bottom lands are seasonally flooded as a function of high spring flows and topography. Floodplain depressions, oxbows and backwaters provide warm, shallow, quiet refugia for young fish. These refugia must be available for larvae as they drift downstream from spawning sites upstream on the Yampa and Green rivers. The Recovery Program has given high priority to acquiring, in fee or by easement, restoring and managing these bottomlands to improve their floodability to provide nursery habitats for the endangered fishes. Because these Green River habitats are downstream from the Yampa River confluence, they are impacted by depletions from the Yampa River. Moreover, these habitats directly benefit Yampa River Colorado pikeminnow and razorback populations by promoting survival and recruitment of young fish into these populations.

Under Section II.A.2. of the Green River Action Plan: Mainstem, the Recovery Program is actively seeking to acquire and improve floodplain habitats for the endangered fishes along the Middle Green River between Ouray and Jensen. Specific recovery actions under this section of the RIPRAP include identifying and evaluating high-priority flooded bottomland habitats and acquiring an interest in the best habitats either in fee or by easement. Section II.A.3. of the Green River Action Plan provides for improving their habitat value by removing levees to allow spring floods to inundate floodplain depressions, overflow channels, backwaters and oxbows, which serve as nursery habitats for Yampa/Green river populations of razorback sucker and Colorado pikeminnow. This activity is expected to continue through FY 2003.

Restore Native Fish Passage at Instream Barriers and Reduce Impacts of Maintaining Diversion Structures

The Recovery Program has undertaken several studies to determine whether existing diversion structures on the Yampa River within critical habitat impede endangered fish migration. Modde et al. (1999) specifically examined the Maybell and Patrick Sweeney diversions during the low-flow period (August-October) in 1996 and 1997. They found that Colorado pikeminnow migrated upstream from their spawning sites on the descending limb of the hydrograph when water depth and velocity allowed them to move freely across these structures. These long-distance migrations occurred only immediately before and immediately after spawning. Their movements during the remainder of the year were not constrained by man-made barriers any more than they were by natural barriers, such as shallow riffles. Therefore, no remedial action is required to facilitate fish passage at the existing facilities.

Nevertheless, new diversion structures constructed within critical habitat could affect fish passage. New structures, in this case, includes reconstruction or other modification of existing structures such that their levels of incidental take, individually or cumulatively, exceed those anticipated in a Yampa PBO. The Recovery Program will develop guidelines to ensure that any new structures constructed within critical habitat are designed to allow for fish passage with the incremental construction cost, if any, to be borne by the project proponent(s).

Pursuant to Section II.A.1.c. of the FY 2002 Green River Action Plan: Yampa and Little Snake Rivers, the Recovery Program will develop design guidelines for new diversion structures and other dams constructed in critical habitat on the Yampa River to facilitate fish passage. New structures include any existing structures modified such that they may become barriers to passage of endangered fishes, thereby increasing levels of incidental take in excess of that anticipated by a Yampa PBO. Adherence to these guidelines may be a condition of any federal permit required for the project or, if no other federal permit is required, an incidental take permit issued by the FWS pursuant to Section 10 of the ESA.

Reduce/eliminate Entrainment of Colorado Pikeminnow at Diversion Structures

We do not know if endangered fish currently are being entrained by, or otherwise enter, existing water diversion canals, resulting in the loss (i.e., incidental take) of these individuals. If such a problem exists, it would be limited in scope (i.e., in occupied habitat only). Larval life stages are most susceptible to entrainment. However, in the recent past, endangered fishes have not been found to spawn upstream from Yampa Canyon. Therefore, we do not expect larval fish to suffer from entrainment, since all major water diversions on the Yampa River are upstream from Yampa Canyon. Moreover, razorback sucker, humpback chub and bonytail do not occur in significant numbers upstream from Yampa Canyon. However, adult/subadult Colorado pikeminnow do occupy the reach downstream from Craig and could enter canals within this reach and become trapped or stranded. The Recovery Program will undertake a study beginning in FY 2002 to determine whether and to what extent Colorado pikeminnow may enter canals and, if necessary, bear the cost of modifying existing diversions to minimize or prevent entry by Colorado pikeminnow. The Recovery Program also will develop guidelines to minimize or prevent entry of Colorado pikeminnow into canals at new facilities proposed for construction or modification (e.g., replacing a temporary structure with a permanent one) with any incremental construction costs to be borne by source(s) outside the Recovery Program. New facilities, in this case, includes any reconstruction or modification of existing structures such that their levels of incidental take, individually or cumulatively, exceed those anticipated by a Yampa PBO.

Pursuant to Section II.A.2.a. of the FY 2002 Green River Action Plan: Yampa and Little Snake Rivers, the Recovery Program will identify and evaluate existing diversions for their potential to entrain or otherwise attract Colorado pikeminnow. Existing facilities found to entrain or attract Colorado pikeminnow would be remediated at Recovery Program expense, pursuant to Section II.A.2.b. of the Action Plan.

Under Section II.A.2.c. of the Action Plan, the Recovery Program will develop guidelines to reduce or eliminate entrainment at new diversion structures on the Yampa River in the critical habitat reach (Echo Park to Craig, Colorado). New structures includes any existing structures modified such that entrainment of endangered fishes results in levels of incidental take in excess of those anticipated in the Yampa PBO. Adherence to these guidelines may be a condition of any federal permit required for the project or, if no other federal permit is required, an incidental take permit issued by the FWS pursuant to Section 10 of the ESA.

Manage Genetic Diversity/Augment or Restore Populations

Supplemental stocking with fish propagated from captive brood stocks is not intended to replace natural reproduction and recruitment. However, maintaining the genetic integrity of wild and captive-reared endangered fishes is important to their recovery and to preventing irreversible losses of genetic diversity. The Recovery Program has developed the following genetic management goals: (1) prevent immediate extinction; (2) conserve genetic diversity through recovery efforts that will establish viable wild stocks by removing or significantly reducing factors that caused the population declines; (3) maintain the genetic diversity of captive-reared fish; and (4) produce genetically diverse fish for augmentation efforts (Czapla 1999).

Supplementing the Middle Green/Lower Yampa razorback sucker population is a high priority of the Recovery Program, which also will stock Bonytail within the lower reaches of the Yampa. The presence of stocked hatchery fish can provide an inaccurate picture of the size and health of the wild population. Therefore, fish stocked into the Yampa and Green rivers will be marked to allow the size of the wild population to be differentiated from the size of the stocked population. While stocked fish contribute to the size of the adult population, the overall health of a specific population depends upon successful natural reproduction as indicated by increased numbers of young-of-the-year fish and corresponding increases in the adult population due to recruitment.

Under Section IV.A.1.a. of the Green River Action Plan: Yampa and Little Snake Rivers, the CDOW (1999) developed a plan to stock bonytail in the Yampa River in Colorado. Pursuant to Section IV.A.1.a.(1) of the Action Plan, implementation of this stocking plan began in 2000 and will extend through 2003. To date, a total of 23,000 fingerling (~3 inches long) bonytail have been stocked in the Green River near Brown's Park, Colorado, and in the Yampa River near its confluence with the Green River at Echo Park. Both sites are within DNM, and stocking is being carried out by the CDOW with the cooperation of the NPS.

Monitor Populations and Habitat

Monitoring endangered fish populations and habitat conducive to their recovery is necessary to determine when populations have recovered to the extent that they may be downlisted to threatened status or delisted (i.e., removed from the list of threatened and endangered species). Draft recovery goals have been developed for the four Colorado River endangered fish species. These goals have been excerpted elsewhere in this document. They include both numerical population criteria and habitat criteria needed for recovery. In addition to these recovery goals, separate performance criteria will be developed for each of the recovery actions described above to measure their effectiveness in contributing to the recovery of the endangered fishes. For example, populations of nonnative fishes will be monitored to ascertain the effectiveness of nonnative fish management activities. Declining nonnative fish populations in the river would provide direct evidence that these activities are achieving the desired results, and provide indirect evidence of potential benefits to the endangered fishes and other native species due to reduced predation and competition by nonnatives. However, corresponding changes in endangered fish populations (i.e., increased abundance, expanding range, evidence of spawning and recruitment, etc.) would be required to confirm the beneficial effects of any recovery action.

To accomplish these objectives, adult Colorado pikeminnow and humpback chub and young-of-year Colorado pikeminnow will be monitored at 5-year intervals to ascertain the status of these endangered fish populations. In addition, the Recovery Program will develop and implement a habitat monitoring program to determine the extent to which recovery actions, such as floodplain acquisition and restoration and providing instream flows, have been implemented, and whether these actions have produced positive results (i.e., habitat gain or habitat improvement). The Recovery Program will monitor the direct effects of nonnative fish management in the Yampa River and elsewhere by assessing the populations of nonnative species. A decline in numbers of nonnatives alone suggest presumptive evidence of benefit to the endangered fishes; however, it also will be necessary to examine the population structure of the endangered fishes, as well as surrogate native species, such as roundtail chub and flannelmouth sucker, to confirm that nonnative fish management has, in fact, achieved the desired results. An increase overall abundance, especially in younger, smaller life stages would be a positive sign of survival and recruitment, thereby allowing the endangered fish populations to continue to increase. Using this information, the Recovery Program will re-evaluate the effectiveness of its recovery actions, including those described herein, and may modify those actions whenever it deems such modification(s) necessary and appropriate. The Recovery Program will be responsible for implementing any modifications of, or additions to, the recovery actions described in this plan and bear any incremental increase in costs.

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